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EXPERIMENT STATION RESEARCH ON THE VITAMIN CONTENT AND THE PRESERVATION OF FOODS

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Agricultural Research Administration

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CONTENTS

INTRODUCTION

The previous custom of reviewing the results of research at the State agricultural experiment stations of particular interest to all aspects of home life has been suspended in this report in order to present a rather detailed review of the greatly expanded program of research on the nutritive value of foods as affected by various factors.

The new significance attached to food as an implement of war as well as peace has served to stress the fact that nutritional quality must be considered along with yield, appearance, and other factors in evaluating the importance of a food crop and its priority in a food production program. Furthermore, it is realized as never before that every effort should be made to prevent to the greatest possible extent losses in the nutritive value of foods during all the manipulative processes between production and final consumption. At a time when the food supplies for the armed forces, lend-lease shipments, and rehabilitation work are being allocated on the basis of their nutritive value, when nutrition programs for industrial workers are being established, and when throughout the country Victory Gardens are producing a variety of crops for home consumption, the conservation of nutritive values of foods assumes equal importance with the production of foods of the highest possible inherent nutritive value.

Organization early in 1942, within the framework of the State agricultural experiment stations and the Department, of a National Cooperative Project on the Conservation of the Nutritive Value of Foods served as an impetus to a decided expansion of research in this field.

A greater unification of methodology has been effected through technical committees with regional representation; the organization of the State groups under the leadership of an experiment station director in each region as regional coordinator is affording an opportunity for an exchange of ideas in the assembling of material on a regional basis; and an arrangement for issuing preliminary progress notes by the individual station makes it possible to obviate long delays in releasing data. At the time of writing, July 1943, no less than 43 stations and the Bureau of Human Nutrition and Home Economics are participating in this program. Included in the present report are some of the preliminary findings in projects set up as a part of the National Cooperative Project, although the greater part antedates the organization of the work in this field on a cooperative basis. The entire period reviewed extends from 1941 to as late as July 1943. Summaries of earlier studies are to be found in previous reports of experiment station research, the last two of which cover the periods for 1939-40 *(137)* [1] and 1940-41 *(138)*.

FACTORS AFFECTING VITAMIN VALUES OF FOODS

With recognition of the fact that the dietary vitamin intake is governed not only by the foods included in the diet but also by variations within individual foods, many investigations have been carried out to determine the source and the magnitude of the variations. The studies indicate that there are several stages in which the vitamin content of a food is subject to variation. The first of these is during growth, with the result that a crop as harvested shows certain natural variations in vitamin content. After harvest there are often changes during storage. If the food is processed, as in milling or in preservation by freezing, canning, or dehydration, its vitamin content is further changed, and in the cooking of a food, whether in the fresh or any of its preserved states, there is opportunity for still further change in vitamin content. In the pages that follow an account is given of the studies concerned with these numerous influences.

NATURAL VARIATIONS

Natural variations in the vitamin content of a food as harvested were shown to result from the effects of various factors in operation as the crop was growing. The factors operating included climate and soil, variety, degree of maturity, and selective concentration in different parts of the plant. In foods of animal origin, the vitamin content was influenced by the feed of the animal and the ability of different tissues to store the vitamin.

Effect of climate and soil.—Large variations in ascorbic acid content reported within varieties of strawberries led Burkhart and Lineberry (*21*) to a study of the conditions affecting the vitamin C content. An improved method of extracting the ascorbic acid was employed. This involved emulsification of the sample for 1 minute in a mechanical blender with a metaphosphoric acid mixture. The determination was completed by titrating the centrifuged extract immediately with an electrometric titrimeter, according to the method of Kirk and Tressler (*73*). In checking possible causes of such variation, using North Caro-

[1] Italic numbers in parentheses refer to Literature cited, p. 82.

lina berries of known history, it was found that the ascorbic acid content of sun-ripened berries was greater than that of berries ripened in the shade, and that similarly sampled berries from different fields varied appreciably in ascorbic acid content.

This difference between fields, associated with the effect of soil variation, was observed in Klondike strawberries from six fields, two experimental and four commercial, all receiving the same fertilizer treatment. The ascorbic acid in the berries by fields ranged from 36 to 52 milligrams per 100 grams although close agreement was found between duplicate quarts sampled under the same conditions as to location, time, degree of maturity, exposure to sunshine, and size of fruit. This range showed that different environments markedly affected the ascorbic acid content. From these results it was apparent, in the case of strawberries at least, that any comparison of the ascorbic acid content of different varieties, or any study of the effect of different treatments on ascorbic acid in a single variety, must involve considerable care to eliminate other sources of variation.

Montana-grown strawberries analyzed for ascorbic acid by Mayfield and Richardson (*94*) showed the same wide variations within varieties that were found in the North Carolina berries. Again, the variations appeared to be associated with differences in environmental conditions existing within a given field, on the one hand, and between seasons, on the other hand. Thus, berries of the Dunlap variety, always obtained from the same plot in Gallatin Valley, showed somewhat different ascorbic acid values for two seasons, and berries of the Gem variety, always obtained from the same plot in the Bitterroot Valley, showed evidence of decline in the values as the season progressed. Even at a given harvest there was a wide range in the values obtained for different lots of both the Dunlap and the Gem varieties. The values obtained are given in table 1.

TABLE 1.—*Ascorbic acid values of Montana-grown Dunlap and Gem strawberries tested when fresh*

Variety	Season	Tests	Ascorbic acid per 100 grams	
			Average	Range
		No.	*Mg.*	*Mg.*
Dunlap	1940	10	79	65–89
Dunlap	1941	8	64	52–86
Gem Everbearing	1941, first crop[1]	8	80	69–89
Gem Everbearing	1941, first crop[2]	16	67	56–91
Gem Everbearing	1941, second crop[3]	11	61	49–77

[1] Picked July 1, at height of first bearing period.
[2] Picked July 29, at end of first bearing period.
[3] Picked August 26, at height of second bearing period.

The influence of locality and season on ascorbic acid content was apparent in the case of tomatoes of four varieties grown in 1938 and 1939 in four widely separated localities in Maine. The data obtained in this study by Murphy (*108*) showed that varietal differences were similar in the 2 years, with Penn State Earliana having the lowest ascorbic acid value and Bestal the second lowest in all four localities, and with Comet highest at Orono and Kennebunk and Best of All highest at Aroostook and Highmoor. In 1938 the majority of samples

from Orono, Highmoor, and Kennebunk were higher in ascorbic acid content, by more than 6 milligrams per 100 grams, than those from Aroostook. The favorable effect of a given location as observed in the first year did not persist over the second year, however, for in 1939 tomatoes grown at Aroostook, while again lower in ascorbic acid than those grown at Orono, were, on the other hand, higher than those grown at Highmoor and Kennebunk. An analogous experiment in which four varieties of cabbage were used for the test crop confirmed the evidence obtained with tomatoes.

These findings indicated that environmental agencies influenced the synthesis of ascorbic acid in tomatoes and cabbages and that geographic situation was not a contributing factor except insofar as environmental conditions were characteristic of that situation. An analysis of available weather data suggested that sunlight, rainfall, and probably temperature might have been causal agents in the variations in ascorbic acid content. As the tissue matured there was a definite rise in ascorbic acid concentration in the tomato and a decline in the cabbage. These phenomena were related to geographical situation to the extent that maturity rate was hastened or delayed by the climatic condition prevailing throughout the growing season.

In tests at the South Dakota station to determine the effect of cultural practices on the yield and quality of garden vegetables, McCrory and Snyder [2] grew the vegetables under lath shade and in the open. Three fertilizer treatments were used. Although the fertilizer influenced the yield—plots treated with Vigoro yielded highest, followed by those treated with manure, superphosphate, and the check plots—it caused no consistent variations in the vitamin content of the crops. In this particular season, which was cold and wet, the yields were consistently higher in the open than under shade. As for the vitamins, carotene was a little higher under shade, while ascorbic acid was considerably lower.

The effect of environment on the content of ascorbic acid was also observed in rhubarb grown at the Washington station. In this case, two varieties were grown over two seasons, both in the hothouse and in the field, and stalks harvested at prime maturity were analyzed. The analyses of each lot were made on composite samples of center sections from several stalks. A summary of the data from these determinations, made by Todhunter (*144*), showed the field-grown rhubarb to be consistently richer in ascorbic acid than the corresponding lots grown in the hothouse. The values obtained are reported by range in table 2.

TABLE 2.—*Ascorbic acid in hothouse- and field-grown rhubarb*

Variety	Ascorbic acid per 100 grams	
	Hothouse-grown	Field-grown
	Mg.	*Mg.*
Fresh mature rhubarb:		
Victoria	3.5–5.8	6.8– 8.0
Wine	5.8–6.7	6.5–16.7

[2] MCCRORY, S. A., and SNYDER, L. C. PROGRESS REPORT ON RESEARCH PROJECT 118. IMPROVING VEGETABLE YIELDS AND QUALITY BY CULTURAL PRACTICES. S. Dak. Agr. Expt. Sta. Hort. Pam. 26, [4] pp. 1943. [Processed.]

Effect of variety.—The preceding studies have indicated that environmental, soil, and climatic factors all influence the nutritive value of a food crop. Although variations effected by environment may be of sufficient magnitude to mask varietal differences, this does not lessen the importance of varietal values in assessing the nutritive content of a food crop. A number of investigations of varietal differences in ascorbic acid content have been carried out. In these studies the several varieties of the crop were grown under comparable soil and climatic conditions so that the differences observed represented essentially those due to variety.

Varietal differences in Fairmore, Missionary, Massey, and Blakemore strawberries were studied by Burkhart and Lineberry (*21*) with careful attention to sampling in accordance with their observations as noted above. These varieties, grown at Willard, N. C., in the same field at the same fertility level and harvested when ripe, averaged, respectively, 66, 46, 42, and 33 milligrams of ascorbic acid per 100 grams. A similar study of other kinds of berries grown under comparable conditions in this North Carolina region, and sampled when ripe, was made by Lineberry and Burkhart (*83*). Varietal differences existed in regard to ascorbic acid values, as is evident from the average values tabulated below (table 3).

TABLE 3.—*Varietal differences in ascorbic acid content of berries*

Fruit and variety	Ascorbic acid per 100 grams	Fruit and variety	Ascorbic acid per 100 grams
	Mg.		*Mg.*
Blueberries:		Dewberries:	
Cabot	18.6	Young	32.5
Rancocas	18.4	Lucretia	27.0
Scammell	16.5	Boysen	25.9
Concord	16.0	Raspberries:	
Blackberries:		Dixie	32.5
Early Wonder	23.5	Latham	23.5
Brainard	12.9	Newburgh	20.5

The ascorbic acid content of seven varieties of muscadine grapes was investigated by Bell et al. (*8*). All varieties were grown in North Carolina in 1937, 1938, and 1939 on the same type of soil and with the same fertilizer treatment. The fruits analyzed were firm and ripe and of characteristic size for each variety. The ascorbic acid content, as determined by the method of Mack and Tressler (*89*), averaged 6.8 milligrams per 100 grams of the edible portion of ripe scuppernong grapes and from 4.1 to 5.5 milligrams per 100 grams of the Labama, Eden, Thomas, and James varieties. The Mish and Hopkins varieties contained negligible quantities, averaging 1.8 and less than 0.2 milligrams per 100 grams, respectively.

In the studies just discussed, ascorbic acid has been shown to vary characteristically with different varieties. This influence of variety has been reported also in recent studies on the vitamin A content of fruits. Determinations by Reynolds and Cooper as reported by the Arkansas station (*3, p. 19*), showed that peaches may be a good or a poor source of carotene (provitamin A), depending largely on the variety. Among the 17 varieties of Arkansas-grown peaches examined, the carotene content ranged from approximately 20 to 500 micrograms per 100

grams of peach, or the equivalent of 33 to 833 International Units. The average carotene content of Elberta peaches, the variety most widely grown in Arkansas, was 290 micrograms per 100 grams of peach. Chilow, Leona, Rochester, Halehaven, Elberta Cling, Anabel, Ideal, Fair Beauty, and Golden Jubilee varieties did not differ significantly in carotene content from Elbertas, ranging in the order named from 350 to 210 micrograms per 100 grams of fruit. Two varieties, Early Crawford and Wilma, were significantly richer in carotene than Elberta, and five varieties, Golden Elberta, Mikado, St. John, Belle, and Lola Queen, were comparatively low in carotene. Of these low-carotene varieties, the three latter were white-fleshed and could not be considered significant as sources of vitamin A, since their carotene contents were less than 24 micrograms per 100 grams.

According to Schroder et al. (*132*), the ascorbic acid content of peaches does not show the marked variation by varieties that was observed by Reynolds and Cooper in carotene. In the eight varieties of peaches obtained from a restricted area near Raleigh, N. C., and with individual fruits selected for similarity of size and degree of ripeness, ascorbic acid varied only from 3.84 milligrams per 100 grams for the Augbert to 12.86 milligrams for the Hiley. The extreme difference between varieties was only 9.02 milligrams per 100 grams of fruit, whereas the average difference within varieties was 4.29 milligrams per 100 grams.

Six varieties of avocados grown at the subtropical station at Homestead, Fla., were analyzed by French and Abbott (*60*) for carotene and ascorbic acid. In this fruit also, vitamin differences by varieties were evident (table 4), although the order with regard to ascorbic acid level was not the same as that for carotene content. In the former case the earlier varieties were higher in vitamin C, but this factor did not consistently affect the carotene content.

TABLE 4.—*Varietal differences in ascorbic acid and carotene contents of avocados*

Variety	Ascorbic acid per 100 grams	Carotene per 100 grams
	Mg.	*Mg.*
Pollock	37	510
Trapp	31	140
Waldin	28	410
Lula	13	130
Booth "8"	10	240
Collinson	7	280

The ascorbic acid content of mangoes grown in Hawaii was found by Miller and Louis to vary greatly with the variety. Their data, as reported by the Hawaii station (*65, p. 134*), showed that of the samples tested, the common mango (Manini) had the highest value, or 114 milligrams per 100 grams of fruit, followed by the Wootten with 90 milligrams, Bishop with 33 milligrams, and the Haden and Pirie with 14 milligrams. The Pirie mangoes, although of superior flavor and texture, showed consistently low ascorbic acid values in samples collected from three locations in two seasons.

Among vegetables, an example of variation in vitamin level associated with varietal differences was found in the data obtained by Murphy

(*107*) on the ascorbic acid content of Maine-grown onions. These values are summarized in table 5. In one phase of the study the inner central part of mature onions, consisting of the younger smaller leaves, was analyzed separately from the outer part, made up of physiologically older tissue. In each of 10 varieties the ascorbic acid of the central part exceeded that of the periphery, and differences between varieties were caused principally by variations in this central part.

TABLE 5.—*Ascorbic acid in different varieties of fresh raw onions grown at Orono, Maine*

Variety	Ascorbic acid per 100 grams in—	
	Mature and immature samples[1]	Mature samples[2]
	Mg.	*Mg.*
Early Red Globe	40	----------
Yellow Globe Danvers	36	----------
Silverskin White Portugal	34	----------
Brigham Yellow Globe	33	----------
Early Yellow Globe	31	----------
Southport Red Globe	30	22
Mountain Danvers	30	----------
Southport Yellow Globe	27	18
Earliest White Queen	22	17
Riverside Sweet Spanish	21	17
Southport White Globe	21	16
White Sweet Spanish	20	14
Extra Early Yellow	20	13
Ebenezer	19	13
Yellow Bermuda	19	18
Crystal White Wax	17	15

[1] The values include data on immature and mature onions harvested at intervals from Aug. 1 to Sept. 23, 1938.
[2] Onions at least 1 inch in diameter.

Effect of maturity.—These results with onions suggest that stage of maturity may often be a factor influencing the vitamin content of a fruit or vegetable sample. Thus, in the study by Murphy, the small immature onions, harvested early in the season while still small and straight, were higher in ascorbic acid content than larger onions harvested later in the season. In the comparison of the younger smaller leaves, constituting the central part of the bulb, with the older outer leaves, the former were found to contain from 0.14 to 0.73 milligram per gram, while the latter contained from 0.04 to 0.13 milligram.

Although onions apparently decreased in ascorbic acid content with increasing maturity, peppers were found by Lantz (*82, 111*) to increase markedly in ascorbic acid as the fruit matured. This increase in vitamin value as the peppers ripened was still more pronounced in the case of carotene, amounting in the variety Hungarian Paprika, for example, to as much as a fiftyfold increase in concentration between the immature green and the red ripe samples analyzed. These changes in vitamin concentration with increasing maturity are shown by the data taken from the study by Lantz and summarized in table 6. Here varietal differences in peppers were evident, although pungent varieties as a class apparently were not different from the sweet varieties. Maturity differences, however, were so much greater than varietal differences that any comparison of the vitamin content of different varieties would seem to necessitate great care in the matter of sampling.

TABLE 6.—*Carotene and ascorbic acid content of peppers (sweet and pungent varieties) grown at the New Mexico Agricultural Experiment Station*

Variety	Color	Carotene per 100 grams			Ascorbic acid per 100 grams		
		Immature	Partly ripe	Ripe	Immature	Partly ripe	Ripe
		Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*
White Casaba	Yellow	0.09					
	Green		0.20				
	Red			4.17			
Florida Paprika	Green	.63			99		
			2.18			251	
	Red			13.74			278
Long Red Paprika	Green	.55			115		
	Green side					202	
	Red side					261	
	Red			9.50			560
Hungarian Paprika	Green	.43					
	Red			22.61			
Jubilee of Honor	Yellow	.03					
	Orange	.12					
Bell	Green	.36			248		
	Red			12.38			
Chile No. 9	Green	.49			254		
						308	
	Red			11.93			326
Anaheim Chile	Green	.56					
			3.14				
	Red			11.40			

Carrots of six varieties grown in Colorado were found by Pyke and Charkey (*124*) to increase rapidly in vitamin A (carotene) value during the growing season. Harvested as baby carrots, these varieties, planted early in the season, averaged 74 micrograms of carotene per gram of sample (range by varieties, 70 to 85 micrograms); corresponding samples harvested as mature carrots of at least 2 inches crown diameter averaged 180 micrograms per gram (range, 146 to 255). In other trials the same varieties planted later in the season averaged 84 micrograms per gram (range, 65 to 102) when harvested as baby carrots and 215 micrograms (range, 161 to 282) when harvested as mature samples. These maturity differences in carotene content were much more pronounced than the varietal differences observed. In the case of ascorbic acid, varietal differences were slight, and from bunching size (¾ to 1 inch in diameter) onward the stage of maturity of the carrots did not seem to influence the ascorbic acid content of the tissue.

Increase in ascorbic acid content with increasing maturity was observed in strawberries by Burkhart and Lineberry (*21*) and in blueberries and blackberries by Lineberry and Burkhart (*83*). These fruits were grown in North Carolina. In Klondike strawberries the ascorbic acid content increased from 59 milligrams per 100 berries (244 grams) in the case of green berries to 280 milligrams per 100 berries (605 grams) in the ripe fruit. This represented a twofold increase in concentration —from 24 to 46 milligrams per 100 grams—and almost a fivefold increase in the amount of ascorbic acid elaborated as the berries grew and matured. Blueberries of the Scammell variety contained but 3.3 milli-

grams of ascorbic acid per 100 grams when green, as compared with 16.5 milligrams when ripe, and Brainerd blackberries increased from 11.6 to 12.9 milligrams of ascorbic acid per 100 grams as the berries progressed from the red to the ripe stage.

Cantaloups grown at the Arizona station were analyzed for ascorbic acid content by Smith, Burlinson, and Griffiths,[3] who employed the analytical method of Morell (*99*). As part of this study, the effect of stage of maturity on vitamin C in Arizona strain No. 45 was investigated. The results obtained showed that in this fruit also the ascorbic acid content increased as the fruit matured. Green melons of the first harvest averaged 29.5 milligrams of ascorbic acid per 100 grams of edible portion; this amount increased with successive harvests until at the time of the fourth harvest, when the cantaloups were fully ripened, the edible portion averaged 40.6 milligrams per 100 grams. In another group, melons received in an overripened, almost rotten, stage showed a sharp reduction in ascorbic acid to the point of containing only about one-half as much vitamin as did the mature edible melons.

Honeydew melons analyzed as part of this study showed the same tendency as did the cantaloups, namely, to increase in ascorbic acid as they matured but to decline as they passed the prime ripe stage. When picked green they averaged only 16.7 milligrams of ascorbic acid per 100 grams of edible portion (range, 14.2 to 20.7 milligrams); when picked "field ripe" but not full ripe and analyzed after shipping they contained 25.6 milligrams per 100 grams (20.8 to 27.6); but when picked fully ripe and then shipped the shipped samples averaged but 18.8 milligrams per 100 grams (range, 14.4 to 20.9).

The influence of the stage of maturity on the ascorbic acid content of peaches was investigated by Schroder et al. (*132*). In seven of the eight varieties grown in commercial orchards near Raleigh, N. C., peaches picked at the hard (green) stage were lowest in ascorbic acid. Successive samples picked through the various stages of ripeness classified as firm (hard ripe or shipping stage), ripe, and soft (overripe) showed a continuous increase in ascorbic acid concentration. This variation is indicated by the data in table 7.

TABLE 7.—*Relation of ascorbic acid content to ripeness of peaches*

Variety	Peaches	Average ascorbic acid content per 100 grams			
		Hard	Firm	Ripe	Soft
	No.	*Mg.*	*Mg.*	*Mg.*	*Mg.*
Early Wheeler	28	4.05	5.35	7.36	8.28
Golden Jubilee	23	3.78	4.25	6.13	7.71
Elberta	22	4.39	4.45	5.25	----------
Hiley	21	6.84	8.56	12.86	14.05
Mayflower	20	----------	4.59	5.34	5.57
Early Rose	20	5.31	5.36	7.18	----------
Carman	14	----------	6.06	8.82	10.53
Augbert	8	5.36	4.55	3.84	----------

Of the several fruits just considered, it was apparently characteristic for the vitamin content, ascorbic acid in particular, to increase with increasing maturity. This was not the case, however, with mangoes

[3] SMITH, M. C., BURLINSON, L. O., and GRIFFITHS, A. E. CANTALOUPE—AN EXCELLENT SOURCE OF VITAMIN C. Ariz. Agr. Expt. Sta. Mimeographed Rpt. 53, 8 pp. 1943. [Processed.]

grown in Hawaii and analyzed by Miller and Louis (*65*). According to their analyses, green mangoes of the five varieties tested contained more ascorbic acid than the ripe ones.

Effect of part sampled.—As pointed out in the discussion of onions (see p. 7), the ascorbic acid content was not uniformly distributed throughout the bulb but was present in higher concentration in the inner than in the outer part. The red side of the partly ripe pepper, as analyzed by Lantz and reported by the New Mexico station (*111*), was found to be richer than the green side in ascorbic acid. These differences in vitamin content were apparently associated with the fact that not all parts of the food sample were developed to the same degree of maturity.

In other cases this lack of uniformity of vitamin concentration throughout the sample was associated with selective distribution of the vitamin in different structural parts of the grain, fruit, or vegetable. Thus, in the cereals, Kik (*72*) (Arkansas) found thiamine of rice to be concentrated in the outer bran layers and the germ; and Teply et al. (*143*) (Wisconsin) also found nicotinic acid, pantothenic acid, and pyridoxine to be concentrated in the bran and the germ of wheat. In fruits the vitamin concentration was often higher in the outer than in the inner parts. For example, the concentration of ascorbic acid in scuppernong grape skins was about three times as high as in the edible portion, according to Bell et al. (*8*); and nicotinic acid concentration in apple skins analyzed by Teply et al. (*142*) was about twice that in the flesh. Outer parts of strawberries and peaches were richer than the center portions in ascorbic acid according to analyses by Burkhart and Lineberry (*21*) and Schroder et al. (*132*), respectively. Among vegetables, the parsnips used by Brown and Fenton (*18*) (New York (Cornell)) did not have the ascorbic acid uniformly distributed between tip and upper parts or between medulla and cortex; the buds of fresh broccoli analyzed by Barnes et al. (*5*) (New York State) were richer in ascorbic acid than were the stalks; and leaf blades of various greens were found by Sheets et al. (*134*) (Mississippi) to be richer than the petioles in carotene and ascorbic acid.

These examples of variable distribution of vitamins within a food are in many cases chiefly of interest to the analyst who is charged with the responsibility of selecting the analytical sample in such a way that it will be representative of the food as eaten. In other cases these variations are of importance in selecting and preparing foods with a view to obtaining maximum food value compatible with good culinary practice.

Effect of feeding practice.—The influence of the ration of the animal on the nutritive quality of food of animal origin is illustrated by the results obtained at the North Dakota station by Christensen, Knowles, and Severson (*27*), who investigated the effect of the ration on the nicotinic acid content of pork. They analyzed the livers, loins, and hams of pigs from different lots fed, for 113 to 138 days, the same basal feed mixture but supplemented in the different groups with 100, 300, or 500 milligrams of nicotinic acid per head daily. The nicotinic acid content of the tissues of these animals and of two control groups receiving no nicotinic acid supplement was compared with that of tissues from control pigs analyzed at the beginning of the experiment. The data, summarized in table 8, showed that the liver was much richer than the muscles in nicotinic acid, but that the amount stored

in the liver bore no relation to the amount in the ration. In the loins and the hams, however, the nicotinic acid stored reflected the increase in the amounts of nicotinic acid fed. Neither the basal feed mixture alone nor this supplemented with alfalfa pasture increased the nicotinic acid in the loins and hams.

TABLE 8.—*Influence of ration on the nicotinic acid content of pork.*

Group	Nicotinic acid fed per head daily	Nicotinic acid per 100 grams					
		Liver		Loin		Ham	
		Fresh basis	Moisture-free basis	Fresh basis	Moisture-free basis	Fresh basis	Moisture-free basis
	Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*
Check group[1]	None	15.7	55.2	4.3	17.8	6.0	25.8
Control groups:[2]							
Feed mixture alone	do	13.5	50.9	4.7	18.5	5.7	24.2
Feed mixture +alfalfa pasture	do	13.7	49.2	4.7	17.6	5.2	20.7
Test groups:[2]							
1. Feed mixture +nicotinic acid	100	15.1	53.9	7.4	28.3	7.4	30.6
2. Feed mixture +nicotinic acid	300	14.5	52.7	8.1	32.5	7.8	32.9
3. Feed mixture +nicotinic acid	500	14.8	54.8	8.9	36.3	8.8	36.9

[1] Analyzed at beginning of experiment.
[2] Analyzed at end of experiment.

A similar study, designed to show to what extent the thiamine content of pork is influenced by the thiamine intake of the pig, was carried out at the Pennsylvania station. In these tests, reported by Miller et al.,[4] pigs in three lots were fed for 118 days, during which time they all consumed essentially the same amount of the basal feed mixture, but received in their feed thiamine supplements amounting to 7, 18, and 29 milligrams per pig per day in the three lots, respectively. Analyses of various tissues of the pigs slaughtered at the end of the experiment showed that the thiamine tended to deposit in the muscle tissue, and that there was a positive relationship between the thiamine intake and the thiamine content of the pork muscle. Thus, increasing the thiamine intake from 7 to 18 milligrams per day resulted in an increase of approximately 100 percent in the thiamine content of the pork shoulder and loin (the thiamine content of the shoulders was from 20 to 30 percent lower than that of the loins). A further increase of intake to 29 milligrams per day resulted in a further increase of 15 to 20 percent in the content in pork muscle. In the case of the liver the same relationship existed but was not as striking as in the case of muscle tissue because of the relatively low thiamine content of pork liver. The values obtained are summarized in table 9.

Incidental to this study the riboflavin values of the pork were determined. The results indicated that the riboflavin was concentrated in the liver rather than in the muscle and that the riboflavin content of the various tissues bore no particular relationship to the riboflavin in the feed, at least at the levels fed (1,669–2,468 micrograms per pound of feed). The livers contained from 40.5 to 43.8 micrograms of ribo-

[4] MILLER, R. C., PENCE, J. W., DUTCHER, R. A., and others. THE INFLUENCE OF THE THIAMINE INTAKE OF THE PIG ON THE THIAMINE CONTENT OF PORK. Pa. State Col. Natl. Coop. Proj., Conservation of Nutritive Value of Foods. Prog. Notes, 3 pp. [1943.] [Processed.]

TABLE 9.—*The thiamine content of pork as influenced by the content of the feed*

Item	Thiamine		
Thiamine in feed—μg. per lb.	5,761	3,447	1,315
Average daily thiamine intake—mg.	29	18	7
Average thiamine content of pork:—μg. per gm.			
Shoulder:			
Fresh basis—do	17.3	15.1	7.9
Moisture-free basis—do	64.8	53.1	28.3
Center loin:			
Fresh basis—do	23.1	20.0	9.5
Moisture-free basis—do	83.5	72.8	32.8
Ham end of loin:			
Fresh basis—do	23.9	20.1	10.3
Moisture-free basis—do	88.8	72.0	36.6
Liver:			
Fresh basis—do	5.3	4.5	3.3
Moisture-free basis—do	17.5	14.5	10.8

flavin per gram of fresh tissue, and the shoulders and loins from 2.2 to 3.5 micrograms per gram (fresh basis).

COMMON STORAGE

With the shipping, storage, and marketing of commercial fruit and vegetable crops, considerable delay usually occurs between harvest and preparation for the table. Even products from the home garden may be held under varying conditions for shorter or longer intervals, including periods of winter storage. It is known that vitamin losses may occur in these storage periods, the extent of loss depending upon the storage conditions and the vitamin concerned. Recent investigations at a number of the experiment stations have dealt with such storage losses, particularly with respect to ascorbic acid. These studies are summarized briefly, by commodities, in the following paragraphs:

Beans.—Ascorbic acid in green snap beans was found to be greatly affected by methods of handling before and after cooking and canning, in tests at the Wyoming station (*164*). In the storage tests it was found that beans held in the refrigerator for 48 hours lost 60 percent of their ascorbic acid.

Cabbage.—Marked loss of ascorbic acid upon holding vegetables in the refrigerator was observed also by Clayton and Borden (*30*) in the case of cabbage. Cabbages of the Danish Ballhead variety raised in Maine and obtained from a commercial cold-storage plant averaged about 48 milligrams of ascorbic acid per 100 grams at the time of purchase. However, after being kept for about a week in an electric refrigerator the values fell to as low as 23 milligrams. In a personal communication to Clayton and Borden, Murphy noted that she had found the vitamin C of cabbage to be quite well preserved when the vegetable was stored at 0° C.

Onions.—The effect of storage on the ascorbic acid content of onions was investigated by Murphy (*107*) in tests with 10 varieties grown at Orono, Maine. The onions for storage were harvested in the middle of October 1938, tied in bunches, and hung in a cool dry attic for 3 months. During the last month of storage the temperature averaged 49.5° F., with readings at 32° or below on 7 days and as high as 58° on 2 days. As shown by the data summarized in table 10 the onions

lost ascorbic acid in storage, the content of this vitamin averaging 13, 10, and 9 milligrams per 100 grams after 1, 2, and 3 months, respectively. As compared with average values for mature onions (1 inch or more in diameter) of these varieties harvested at intervals throughout the season, the stored onions showed ascorbic acid decreases of 20, 36, and 45 percent over the 1, 2, and 3 months of storage, respectively. These represent but approximate losses, since the fresh and stored onions were not strictly paired samples.

TABLE 10.—*Losses in ascorbic acid content of onions upon storage*

Variety	Ascorbic acid content per 100 grams.[1]				Decrease is ascorbic acid values with storage for—			Storage qualities
	Fresh mature onions[2]	Onions stored for—[3]						
		1 month	2 months	3 months	1 month	2 months	3 months	
	Mg.	*Mg.*	*Mg.*	*Mg.*	*Pct.*	*Pct.*	*Pct.*	
Crystal White Wax	15	10			33			Poor
Earliest White Queen	17	17	10	11	0	41	35	Very poor
Ebenezer	13	9	9	9	31	31	31	Good
Extra Early Yellow	13	15			0			Excellent
Riverside Sweet Spanish	17	9	12	6	47	29	65	Do.
Southport Red Globe	22	18			18			Good
Southport White Globe	16	13	12	8	19	25	50	Fair
Southport Yellow Globe	18	16	8	9	11	56	50	Very poor
White Sweet Spanish	14	11	10	8	21	28	43	Excellent
Yellow Bermuda	18	14	11	10	22	39	44	Fair
Average	16	13	10	9	20	36	45	

[1] Reduced ascorbic acid determined by the method of Bessey and King (*9*).
[2] Values represent averages of samples 1 inch or more in diameter as grown at Orono, Maine, and harvested at intervals during the summer of 1938.
[3] Onions harvested October 15, 1938, tied in bunches, and suspended from rafters in a dry attic.

Parsnips.—The parsnips used by Brown and Fenton (*18*) in a study of ascorbic acid losses during cooking were of the Hollow Crown variety, planted in June and dug in November, having been grown on Dunkirk sandy loam in the region of Ithaca, N. Y. Medium-sized parsnips chosen for the study were stored immediately after harvest in a constant-temperature room held at 34° to 35° F. and a humidity of 95 to 100 percent. On the days when ascorbic acid determinations were made some of the parsnips were transferred to the hydrator tray of an electric refrigerator held at 34° to 35°. Values obtained for the raw parsnips showed the effects of storage. During November, December, and January the ascorbic acid content of these carefully stored raw parsnips varied from 15 to 30 milligrams in the individual roots; this range remained fairly constant during the entire period. During February and March, however, the values decreased to a range of 7 to 18 milligrams per 100 grams. The amount of dehydroascorbic acid present varied from 0 to 25 percent, but there was no consistent relationship between the amount present and the length of the storage period. Determinations on different parts of the parsnip showed that the relative distribution of ascorbic acid varied during the storage period.

Peas.—The peas used by Moyer and Tressler (*101*) in a study of thiamine losses in freezing (see p. 21) were harvested from a given field in the region of Geneva, N. Y., and brought to the plant for processing according to regular commercial procedure. When one lot of

Thomas Laxton peas was processed, a delay of 16 hours occurred between the time of harvesting and the time of vining, during which interval the vines were spread out in a thin layer over the viner-shed floor; there was another delay of 3 hours between the time of shelling and washing. In spite of these delays there was little change in the thiamine value of peas.

Todhunter and Robbins (*145*), studying the freezing storage of garden-type peas grown at Puyallup, Wash., found, similarly, in a period of delay in processing and freezing after harvest, that there was little or no change in the ascorbic acid content of peas held in the pod for as long as 8 hours; after 24 hours, however, a 10-percent loss had occurred. When the peas were removed from the pod and held at room temperature, ascorbic acid losses were more rapid, and as much as 21 percent was lost in 24 hours. The data from this study are summarized in table 11.

TABLE 11.—*The ascorbic acid content of fresh peas held at room temperature*

[Tall Alderman variety, sieve size No. 5]

Time of holding (hours)	Ascorbic acid per 100 grams		Ascorbic acid loss
	Moist-weight basis	Moisture-free basis	
Peas held in pod:	*Mg.*	*Mg.*	*Pct.*
0	40	207	
4	42	213	0
8	42	216	0
24	37	187	10
Peas podded and held:			
0	40	207	
4	40	201	3
8	38	194	6
24	41	163	21

Potatoes.—Chemical determinations of ascorbic acid by workers at the Wyoming station (*164*) verified findings by the older biological method, in showing that loss of ascorbic acid from potatoes in storage in the winter and late spring months was very heavy. In the 4-month period January to April, inclusive, the loss amounted to 40 to 57 percent.

Turnip greens.—One purpose of the Southern cooperative study of the ascorbic acid content of turnip greens [5] was to determine the effects of good and poor methods of storage on the retention of this vitamin in the greens. Shogoin and Seven Top varieties were grown at six locations in five Southern States from single seed sources planted in a uniform manner in replicate plantings at all locations. Both spring and fall crops were grown and samples of both varieties from each replicate were collected three times during the growing season. One part of each sample was analyzed at once for moisture and ascorbic acid content; a second part was stored in a refrigerator or cold room at approximately 40° F. for 24 hours before analysis; and a third part was held at room temperature for 24 hours before being analyzed. The results of the analyses, summarized in table 12, show that the ascorbic acid content of the greens was not altered appreciably by storage for 24 hours at 40°; under these conditions the Shogoin and Seven Top

[5] REDER, R. ASCORBIC ACID CONTENT OF TURNIP GREENS. I. EFFECT OF METHODS OF STORAGE. II. EFFECT OF LENGTH OF TIME OF COOKING. Okla. Agr. Expt. Sta. Natl. Coop. Proj., Conservation of Nutritive Value of Foods. Prog. Notes. 2 pp. [1943.] [Processed.]

greens lost, respectively, 5.9 and 3.4 percent of their original ascorbic acid content. At room temperature, however, storage for 24 hours resulted in a marked decrease in ascorbic acid content in both varieties; Shogoin greens lost 21.8 percent and Seven Top greens 32.5 percent.

TABLE 12.—*Effect of storage on the ascorbic acid content of turnip greens*

Variety and state	Moisture content	Ascorbic acid content[1]		Ascorbic acid loss
		Wet basis	Moisture-free basis	
	Pct.	*Mg. per 100 gm.*	*Mg. per gm.*	*Pct.*
Shogoin:[2]				
Fresh	89.49	129.41	12.36	
After storage at—				
40° F., 24 hours	89.09	127.32	11.63	5.9
Room temperature, 24 hours	88.21	115.46	9.66	21.8
Seven Top:[3]				
Fresh	86.62	142.08	10.99	
After storage at—				
40° F., 24 hours	89.22	142.43	10.62	3.4
Room temperature, 24 hours	84.02	119.29	7.42	32.5

[1] Ascorbic acid determined by the method of Morell (*99*) as modified by Loeffler and Ponting (*85*).
[2] 82 samples.
[3] 74 samples.

Apples.—Apples of several varieties furnished by two growers, one at Kearneysville and the other at Romney in the Panhandle section of West Virginia, were analyzed for ascorbic acid as received and after storage for 2 months at 32° F. These analyses, by Fish, as reported by Marsh (*91*), were made by the dye-titration procedure with slight modifications, including electrometric titration of any colored extracts. The data, presented in table 13, show that apples are not rich in ascorbic acid and that the lots tested lost from 12 to 47 percent of the original content after 2 months' storage. The larger losses, 29 and 47 percent, occurred in two lots from Romney, which were higher in ascorbic acid than the corresponding varieties from Kearneysville when first analyzed; at the end of the 2 months' storage this difference was not nearly so great.

TABLE 13.—*The ascorbic acid content of apples as received and after storage for 2 months at 32° F.*

Variety	Source	Ascorbic acid per 100 grams		Loss
		As received	After 2 months' storage	
		Mg.	*Mg.*	*Pct.*
Grimes Golden	Kearneysville	2.59	2.10	18.9
Delicious	do	1.96	1.52	22.5
Starking Delicious	do	2.59	1.52	22.5
York Imperial	do	1.70	1.50	11.8
Stayman Winesap	do	3.74	2.80	25.1
Rome Beauty	do	2.93	2.33	20.5
Grimes Golden	Romney	3.33	2.36	29.1
Delicious	do	4.50	2.40	46.7

TABLE 14.—*Changes in ascorbic acid content of berries during storage*

Condition of fruit and storage temperature	Varieties	Ascorbic acid per 100 grams											
		At beginning		After 1 day		After 2 days		After 3 days		After 4 days		After 6 days	
		Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
	No.	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*
Strawberries:													
Whole, sound—													
Stored at 41° F.	23			57.0	40.5–75.9	54.9	41.3–78.3	55.5	33.5–74.0				
Stored at 77° F.	7			67.8	50.0–85.3	72.6	65.4–82.2	(1)					
Stored at 104° F.	6			52.6	45.2–63.8	54.3	38.5–81.1	(1)					
'Capped"—													
Stored at 77° F.	7	52.5	47.0–60.4	45.5	36.9–57.0	6.0	1.7–11.7	(1)					
Punctured 4 times—													
Stored at 77° F.	7	62.5	55.4–68.8	41.7	30.2–52.0	(1)							
Blackberries:													
Whole, sound—													
Stored at 41° F.	1	22.8				24.7		9.5					
Dewberries:													
Whole, sound—													
Stored at 41° F.	6	25.5	22.8–30.4			28.9	24.7–33.1	4.1	3.8– 4.9				
Raspberries:													
Whole, sound—													
Stored at 41° F.	3	22.2	20.9–22.8			19.9	9.3–29.5	11.4					
Blueberries:													
Whole, sound—													
Stored at 41° F.	10	20.3	17.1–24.7			18.7	17.1–20.9			17.3	13.3–20.9	11.3	0.0–17.1
Stored at 77° F.	8	22.8	19.0–26.6							23.1	15.8–26.6		

[1] Berries had deteriorated, with only traces of ascorbic acid (less than 1 milligram per 100 grams) detectable.

Berries.—Since the ascorbic acid content of berries is one of their important qualities, Lineberry and Burkhart (*84*) were interested in determining the stability of this vitamin in berries under conditions comparable to those met with in commercial shipping and marketing and utilization in the home. The change in ascorbic acid content of North Carolina-grown strawberries, blueberries, blackberries, dewberries, and raspberries was determined after storage at several temperatures and under different conditions for 1, 2, and 3 days and longer, these being the intervals commonly elapsing between harvest and use of commercially shipped berries.

The findings, summarized in table 14, showed that these small fruits, if free from mechanical injury and stored at 41° F., did not lose an appreciable amount of their ascorbic acid within 48 to 72 hours after harvesting. With storage at 77° or 104° the vitamin loss from sound berries was not appreciable in 2 days; in fact, there was some evidence that there was an increase in ascorbic acid on the second day, although, apparently, this was partly due to loss in weight of the berries. After the second day the sound berries lost ascorbic acid very rapidly, so that by the end of the third day only traces remained. Strawberries injured by removing calyxes usually lost a slight amount of ascorbic acid after 1 day and a large amount after 2 days; if punctured to simulate bruising, they lost almost half of their ascorbic acid content after 1 day and all but a trace after the second day. Blueberries retained ascorbic acid longer than the other berries, this relative stability probably being associated with the impervious nature of the skin.

The effect of holding fresh strawberries for several days or of holding berries prepared for table use for shorter periods was investigated by Mayfield and Richardson (*94*) as part of the study of ascorbic acid in Montana-grown berries. (See pp. 23, 32.) They used berries of the Dunlap and Gem varieties obtained from the Gallatin and Bitterroot Valleys, respectively, the latter variety being shipped to the laboratory for testing. The results obtained are summarized in tables 15 and 16. They confirm those of Lineberry and Burkhart, since the fresh berries held at 75° F. showed little change in ascorbic acid in 2 days, whereas those held at 40° in the hydrator pan in the refrigerator lost little or no ascorbic acid even after 5 days. In these tests also, there was evidence of an increase in ascorbic acid on the second day, an increase which the Montana workers associated with a greater degree of ripeness of the berries.

TABLE 15.—*Average ascorbic acid content of fresh strawberries held several days at room temperature or in a refrigerator*

Holding conditions and variety	Ascorbic acid per 100 grams after being held for the period (days) indicated					
	0	1	2	3	4	5
	Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*
Dunlap:						
Uncovered, at room temperature (75° F.)	0.79	0.72	0.71	-------	-------	-------
In refrigerator hydrator pan (40° F.)	.79	.82	.85	0.70	0.75	0.75
Gem Everbearing:						
Uncovered, at room temperature (75° F.)	(1)	.67	.78	-------	-------	-------
In refrigerator hydrator pan (40° F.)	(1)	.67	.66	.66	-------	.68

[1] Berries were in transit.

The adverse effect of hulling and tissue injury was likewise observed in this study. Dunlap berries, which are not very firm, were found to lose some of their ascorbic acid when washed after hulling. This loss, not observed in the Gem berries, was attributed to the fact that a large core often adhered to the hull removed from the Dunlap berry, leaving considerable torn tissue. Berries sliced for table use lost a small amount of ascorbic acid when allowed to stand for 30 minutes (at 75° F.); losses beyond this period were not tested. The addition of sugar to the sliced berries tended to prevent this loss whether the berries were held at room temperature for 30 minutes, or in the refrigerator in a sweetened gelatin desert for 24 hours. It may be noted that this protective action of sugar against ascorbic acid destruction was also suggested by results obtained by Todhunter and Robbins with raspberries frozen with and without sugar. (See p. 23.)

TABLE 16.—*Ascorbic acid content of strawberries variously prepared for the table and held at different periods before use*

Treatment of berries	Ascorbic acid per 100 grams	
	Dunlap	Gem
	Mg.	*Mg.*
Washed before hulling	64	67
Washed after hulling	51	69
Sliced, no sugar added:		
Tested at once	64	67
Tested after 30 minutes (75° F.)	60	63
Sliced, sugar added:		
Tested at once	[1] 64	
Tested after 30 minutes (75° F.)	63	
Sliced, added to sweetened gelatin:		
Tested at once	[2] 64	67
Tested after 24 hours in refrigerator (40° F.)	63	65

[1] Calculated on sugar-free basis.
[2] Calculated on gelatin-free basis.

FREEZING AND FROZEN STORAGE

Comparative analyses of fresh and frozen foods suggest that vitamin losses incurred in the freezing process are relatively small. The extent of the losses can only be determined, however, by attention to weight and moisture changes in connection with the vitamin determinations. Careful studies with regard for all these factors were carried out on a number of foods frozen under controlled conditions. The findings of these studies are discussed with respect to the several fruits and vegetables investigated.

Asparagus.—Changes in the thiamine content of asparagus frozen according to regular commercial procedure were investigated by Moyer and Tressler (*101*) (New York State). For these studies samples taken from one load or field were kept separate and carried through the various processing steps and subsequent storage. The results are presented in tables 17 and 18. On the basis of the washed and cut samples, which were carefully graded according to size of stalk, the authors estimated that the thiamine lost during processing of asparagus harvested at the beginning and at the end of the season amounted to 16 and 20 percent,

respectively. Low-temperature storage (—12° to —40° C.) of the frozen samples for as long as 7 months resulted in no further loss of thiamine.

TABLE 17.—*Thiamine content of asparagus at various stages in processing prior to and after freezing*

Vegetable sample	Early harvest (May 12, 1941)			Late harvest (June 12, 1941)		
	Total solids	Thiamine per gram[1]		Total solids	Thiamine per gram[1]	
		Moist-weight basis	Moisture-free basis		Moist-weight basis	Moisture-free basis
	Pct.	*μg.*	*μg.*	*Pct.*	*μg.*	*μg.*
Raw	9.34	1.83	19.6	8.40	1.74	20.7
Washed and cut	9.10	1.80	19.8	7.86	1.84	23.4
After blanching	9.15	1.60	17.5	7.73	1.56	20.2
After cooling	8.93	1.53	17.1	7.63	1.32	17.3
After freezing	8.70	1.52	17.5	8.51	1.46	17.2

[1] Thiamine determined by the simplified thiochrome procedure described by Moyer and Tressler (*100*).

TABLE 18.—*Conservation of thiamine in frozen asparagus at low temperatures*

Storage temperature	Time in storage	Total solids	Thiamine per gram	
			Moist-weight basis	Moisture-free basis
	Mo.	*Pct.*	*μg.*	*μg.*
	0	8.32	1.58	19.0
—12° C. (10° F.)	7	8.69	1.68	19.4
—22° C. (—8° F.)	7	8.60	1.57	18.2
—40° C. (—40° F.)	7	7.93	1.52	19.2

Beans, snap.—Young green snap beans of the Bountiful variety grown on plots at the Massachusetts station were used by Farrell and Fellers (*56*) in a study of the influence of freezing, canning, and dehydration and subsequent storage on the vitamin content of the beans. In the freezing tests part of the sorted, washed beans were frozen without blanching, while the rest were blanched by dipping in boiling water for 2 minutes and cooled by dipping in cold water. The results, summarized in table 19, show that the frozen beans, if frozen after the preliminary blanching, as is customary in commercial processing methods, lost only 22 percent of their thiamine content, practically none of their riboflavin, and 47 percent of their ascorbic acid even after storage for 12 months at —4° F. The importance of the blanching process is indicated by the much greater losses of the vitamins—74, 39, and 90 percent of the thiamine, riboflavin, and ascorbic acid, respectively—upon freezing and storage without the preliminary blanching process.

Peas.—In a study of the ascorbic acid content of garden-type peas grown at the Western Washington experiment station and preserved by the frozen-pack method, Todhunter and Robbins (*145*) found that the loss of the vitamin occurred, not in the freezing process but in the necessary preliminary blanching of the peas. Peas scalded in steam and frozen on trays without cooling in water retained more ascorbic

TABLE 19.—*Effect of blanching and freezing on vitamin content of green snap beans*

[Bountiful variety, grown at Amherst, Mass.]

Product	Moisture	Vitamin content per 100 grams														
		Thiamine[1]					Riboflavin[2]					Ascorbic acid[3]				
		Raw or newly processed beans			After 1 year's storage at −4° F.		Raw or newly processed beans			After 1 year's storage at −4° F.		Raw or newly processed beans			After 1 year's storage at −4° F.	
		Wet basis	Moisture-free basis	Loss	Moisture-free basis	Loss	Wet basis	Moisture-free basis	Loss	Moisture-free basis	Loss	Wet basis	Moisture-free basis	Loss	Moisture-free basis	Loss
	Pct.	*μg.*	*μg.*	*Pct.*	*μg.*	*Pct.*	*μg.*	*μg.*	*Pct.*	*μg.*	*Pct.*	*μg.*	*μg.*	*Pct.*	*μg.*	*Pct.*
Raw fresh beans	90.6	63	669				132	1,404				26.5	283			
Blanched, frozen in glass container	92.3	77	996	(4)	780	22	156	2,007	(4)	1,947	3	14.5	188	33	150	47
Unblanched, frozen in glass container	90.6	57	612	39	261	74	144	1,530	24	1,230	39	6.5	70	75	27	90

[1] Determined by rat-growth method of Booher and Hartzler (*15*).
[2] Determined by rat-growth method of Bourquin and Sherman (*16*).
[3] Determined by procedure of Mack and Tressler (*89*).
[4] Used as basis for calculating losses.

acid than those blanched by scalding in water at 100° C. for the same period, followed by cooling in water. This latter practice caused a loss of from 30 to 37 percent of the ascorbic acid, but once the peas were frozen there was negligible loss of ascorbic acid upon holding at a storage temperature of 0° F. (table 20).

TABLE 20.—*Effect of scalding and freezing, and subsequent frozen storage on ascorbic acid content of frozen peas*

[Tall Alderman variety]

Description of peas	Ascorbic acid per 100 grams (4 lots, sieve sizes 5 and 6)	Ascorbic acid loss
	Mg.	*Pct.*
Fresh, raw	33–40	
Scalded 1 minute at 100° C. and cooled	24–28	30–37
Immediately after freezing	23–26	Little or no additional loss in freezing and storage
Frozen, stored (0° F.):		
4 months	22–25	
8 months	21–24	
11 months	21–24	

The effect of freezing on the thiamine of peas was investigated by Moyer and Tressler (*101*), who determined the thiamine content at various stages in processing prior to and after freezing. For these studies, samples taken from one load or field were kept separate and processed according to regular commercial procedure. The results, set forth in tables 21 and 22, indicate that the loss in processing the early-

TABLE 21.—*Thiamine content of peas at various stages in processing prior to and after freezing*

Vegetable sample	Thomas Laxton peas Early season harvest (June 20, 1941)			Telephone peas Late season harvest (July 16, 1941)		
	Total solids	Thiamine per gram		Total solids	Thiamine per gram	
		Fresh-weight basis	Moisture-free basis		Fresh-weight basis	Moisture-free basis
	Pct.	*μg.*	*μg.*	*Pct.*	*μg.*	*μg.*
Freshly harvested	16.97	3.11	18.32	18.62	4.33	23.28
Before blanching	16.33	3.08	18.85	18.82	4.21	22.36
After blanching	16.78	2.92	17.93	17.33	3.61	20.82
After quality separation	16.17	2.87	17.74	18.23	3.42	18.75
Before packaging	16.08	2.84	17.65	16.95	2.95	17.40
After freezing	15.69	2.83	18.03	18.75	3.36	17.92

TABLE 22.—*Conservation of thiamine in frozen peas at low temperatures*

Storage temperature	Time in storage	Total solids	Thiamine per gram	
			Fresh-weight basis	Moisture-free basis
	Mo.	*Pct.*	*μg.*	*μg.*
	0	17.97	3.68	20.5
−12° C. (10° F.)	5	17.63	3.59	20.4
−22° C. (−8° F.)	5	17.43	3.62	20.8
−40° C. (−40° C.)	5	17.98	3.68	20.4

season sample of Thomas Laxton peas was small, approximately 5 percent, while a much greater loss, approximately 25 percent, occurred in processing the late-season sample of Telephone peas. The greatest losses of thiamine occurred during blanching and quality separation. After freezing, no significant loss of thiamine occurred at low-temperature storage.

Small thiamine losses in the freezing of peas were also observed by Fincke et al. (*58*) in tests with three varieties grown at Oregon State College and frozen after preliminary blanching and packing in cartons. Thiamine values, determined by the U. S. P. XI rat-curative method, amounted to 3.1, 3.3, and 3.1 micrograms per gram of fresh peas of the Onward, Asgrow, Glacier, and Thomas Laxton varieties, respectively. After freezing of the peas, which resulted in practically no change in moisture content, the respective thiamine values were 2.6, 3.1, and 3.0 micrograms, thus representing losses of 16, 6, and 3 percent, respectively, or, on an average, only about an 8.5-percent loss.

Peaches.—Mature, tree-ripened peaches grown in and around Geneva, N. Y., were used by DeFelice (*43*) in a study of the relative carotenoid (provitamin A) content of the fresh peaches, the frozen sliced peaches that had been lye-peeled, washed, and frozen in 50-percent sirup, and the frozen peach pulp prepared with and without sugar. The data in table 23 show that although the peeling resulted in a loss of approximately 25 percent in provitamin A content, the freezing and freezing storage at —10° F. for 6 months resulted in little or no

TABLE 23.—*Carotenoid (provitamin A) content per gram of fresh peach slices and pulps and of corresponding frozen products stored at —10° F. for 6 months* [1]

Variety	Slices			Pulp	
	Fresh		Frozen (peeled)	Fresh	Frozen
	Unpeeled	Peeled			
	I.U.	*I.U.*	*I.U.*	*I.U.*	*I.U.*
Rochester	26.5	15.3	15.3	16.7	13.2
Elberta	19.6	13.6	14.0	14.1	13.2
J. H. Hale	17.8	13.9	13.4	12.5	12.8
Southhaven	16.7	14.6	14.4	12.3	11.8
Early Crawford	22.5	17.4	17.3	19.3	19.3

[1] Carotenoids (provitamin A) determined by the colorimetric method of Zimmerman et al. (*167*), with the procedure extended to include adsorption on MgO in a Tswett column.

TABLE 24.—*Effect of sucrose concentration on retention of provitamin A potency of frozen peach pulps stored at —10° F.* [1]

Varieties tested (number)	Sucrose concentration (on weight of fruit)	Vitamin per gram [2]
	Pct.	*I.U.*
6	0	11.8–19.3
10	10	11.0–19.3
15	20	10.3–20.9
7	25	10.1–20.5
3	30	13.5–21.0

[1] Carotenoids (provitamin A) determined by the colorimetric method of Zimmerman et al. (*167*), with the procedure extended to include adsorption on MgO in a Tswett column.
[2] Computed on basis of amount of peach originally present in sample.

additional loss. Apparently, added sucrose (10 to 30 percent of the weight of the pulp) exerted no protective action on the provitamin A content at this low temperature, since pulp frozen without sugar retained about the same amount of the vitamin as that frozen with sugar (table 24).

Red raspberries.—In the season of 1939 Todhunter and Robbins (*146*) determined the ascorbic acid content of Washington-grown, firm, ripe, red raspberries immediately upon being brought to the laboratory from the field. Samples from the same berries were packed at once in No. 2, enamel-lined, fruit cans and frozen at 0° F. After storage at this temperature for 9 months, samples were again analyzed. The data are summarized in table 25. The fresh and frozen-pack berries of the same harvesting showed little difference in ascorbic acid content on the moist-weight basis. Calculations to the moisture-free basis indicated, however, that in the freezing and storage period there had been a loss of

TABLE 25.—*Ascorbic acid content of fresh and frozen-pack red raspberries*

Variety and condition	Dry matter	Ascorbic acid per 100 grams[1]		Ascorbic acid loss
		Moist-weight basis	Moisture-free basis	
	Pct.	*Mg.*	*Mg.*	*Pct.*
Cuthbert:				
Fresh	12.7	20	158	
Frozen	15.9	19	120	24
Lloyd George:				
Fresh	9.8	18	184	
Frozen	11.9	17	143	22
Tahoma:				
Fresh	10.7	20	187	
Frozen	11.7	17	145	22
Washington:				
Fresh	13.3	24	180	
Frozen	15.1	22	146	19

[1] Determined by titration with 2,6-dichlorophenolindophenol; checked by photoelectric colorimetric determination.

ascorbic acid ranging from 19 to 24 percent in the several varieties tested. Whether the loss was due to oxidation, or to solution in the ice crystals that separated was not determined. Certain samples of the raspberries were frozen after the addition of sugar; this appeared to have some protective action on the ascorbic acid.

Strawberries.—In the study of Montana-grown strawberries conducted by Mayfield and Richardson (*94*), berries of both the Dunlap and Gem varieties were frozen (1) in a dry-sugar pack, using 1 pound of sugar to each 4 pounds of washed, hulled, sliced berries, and (2) in a sugar-sirup pack in which the washed, hulled berries were packed whole and covered with 65-percent sugar sirup. The berries in sealed pint jars were sharp-frozen at —10° to —20° F. and held in a locker at 0° to —10° for periods up to 6 months. Ascorbic acid determinations, by the method of Bessey and with final readings by means of the Evelyn photoelectric colorimeter, showed that the frozen strawberries, irrespective of variety and type of pack, lost from 10 to 20 percent of their ascorbic acid in the freezing, with progressive losses up to 50 percent in 4 months of freezing storage and about 70 percent in 6 months. The data are given in table 26.

TABLE 26.—*Effect of freezing storage on ascorbic acid content of strawberries*

Variety and condition when tested	Dry-sugar pack		65-percent sirup pack		
	Ascorbic acid content per 100 grams of sugared berry	Ascorbic acid loss	Ascorbic acid content per 100 grams of drained berry	Ascorbic acid content per 100 grams of sirup	Ascorbic acid loss
	Mg.	*Pct.*	*Mg.*	*Mg.*	*Pct.*
Dunlap:[1]					
Before freezing	[2] 51				
Frozen 1–14 days	46	10	57	14	[3] 0
Frozen 2 months	28	46	18	26	39
Frozen 4 months	21	59	14	17	57
Frozen 6 months	14	72	11	14	65
Gem, first crop:[4]					
Before freezing	[2] 64				
Frozen 1–14 days	54	16	48	20	[3] 22
Frozen 2 months	29	55	21	28	45
Frozen 4 months	18	72	19	23	52
Frozen 6 months	18	72	12	16	69
Gem, second crop:[5]					
Before freezing	[2] 49				
Frozen 1–14 days	39	20	36	26	[3] 13
Frozen 2 months	23	57	17	28	34
Frozen 4 months	23	53	20	26	33

[1] Grown in Gallatin Valley, Mont. The fresh berries contained 64 milligrams ascorbic acid per 100 grams.
[2] Calculations based on weight of berries and added sugar.
[3] Calculated by comparing the total amount of ascorbic acid present in berries plus sirup at the beginning of the experiment and at the testing time.
[4] Grown in Bitterroot Valley, Mont. The fresh berries contained 80 milligrams ascorbic acid per 100 grams.
[5] Grown in Bitterroot Valley, Mont. The fresh berries contained 61 milligrams ascorbic acid per 100 grams.

DEHYDRATION

Recent improvements in the methods for drying foods have led to the production of dehydrated products of very acceptable quality. Interest now centers in the ability of these foods to retain their vitamin content along with their flavor, color, and characteristic texture. The few studies dealing with the effects of dehydration on the vitamins in foods are discussed below.

Beans.—The influence of dehydration was investigated by Farrell and Fellers (*56*) as a part of the study of the effect of various processing procedures on the vitamin content of green snap beans. Snap beans of the Bountiful variety, grown at the Massachusetts station, were used in the tests. When blanched for 2 minutes in boiling water, drained, and dehydrated at 130° to 145° F. for 36 hours in a tunnel-type hot-air drier to a moisture content of 2.9 percent, but little of their thiamine and riboflavin was lost in the dehydration and in subsequent long storage. Ascorbic acid, however, was almost totally destroyed by dehydration. The dehydrated beans, soaked 24 hours and cooked, showed losses of thiamine and riboflavin amounting to 45 and 33 percent, respectively. These losses, calculated in terms of the vitamin content of the fresh beans, are summarized in the chart on page 55 in comparison with corresponding losses in the cooked, canned, and frozen snap beans.

Carrots.—Preliminary dehydration tests at the Colorado station (*31*) indicated that carrots should not be allowed to wilt materially before dehydration or the carotene content would be greatly lowered. Colorado-grown carrots, trench-stored until February, brought to the labora-

tory in crisp condition, and then dehydrated, showed in general about 1,000 micrograms of carotene per gram. Carrots from the same lot allowed to wilt for 3 days in the laboratory storage room, then refreshed by immersion in cold water and dehydrated, showed only slightly more than half the carotene content of the samples dehydrated from unwilted stock.

Other tests, by Pyke and Charkey (*124*), showed that with careful attention to blanching, degree of subdivision of the carrots, and the dehydrating procedure, 50 percent or more (50 to 57 percent) of their ascorbic acid could be retained, whereas careless handling resulted in loss of most of this vitamin. Carotene retentions [estimated roughly on the basis of a 10-percent yield of the dehydrated product] obtained with careful handling amounted to as much as 63 to 93 percent. The amount of vitamin destroyed in dehydration and storage increased with increasing subdivision of the material. Thus, the carotene in dehydrated carrot meal, carrot slices (lengthwise), quarters, and halves amounted to 204, 345, 765, and 835 micrograms per gram, respectively. Dehydrated samples (sliced) stored in a cool, dark place in airtight containers assayed 1,222 micrograms of carotene per gram after 10 months' storage as compared with an assay value of 453 micrograms in another sample placed in a loosely closed container in contact with air. These results indicate the necessity of proper storage in order to retain the carotene in dehydrated products.

Peppers.—In experiments on the home drying of "chile" carried out at the New Mexico station some peppers were dried in the sun and others were dried in a home-built dehydrator. Determinations by Lantz (*81, 111*) of the carotene and ascorbic acid content of these dried peppers and of corresponding lots of fresh peppers showed that drying destroyed much of the vitamins, with somewhat greater loss of ascorbic acid than of carotene and with variable losses depending on the method of drying; dehydration caused as much as 55 to 65 percent destruction of these vitamins, while sun-drying caused losses up to 90 percent or more. Data on which estimates of these vitamin losses are based are summarized in table 27. Storage of the dried chile resulted in further vitamin loss, and it was pointed out that in rehydration of the peppers

TABLE 27.—*Peppers: Vitamin losses in drying by home methods*

Peppers	Carotene			Ascorbic acid		
	Content per gram		Loss in drying[1]	Content per gram		Loss in drying[1]
	Fresh basis	Dried		Fresh basis	Dried	
	μg.	*μg.*	*Pct.*	*Mg.*	*Mg.*	*Pct.*
Green:						
Fresh	[4.3]			[1.92]		
Dehydrated	[2] 2.0	24.3	54	[2] .72	8.60	63
Sun-dried	[2] .4	5.8	90	[2] .13	1.56	93
Red:						
Fresh	[112]			[3.45]		
Dried, by various methods:						
Freshly dried	[2] 41	497	63	[2] .12	1.43	96
Stored, ground powder					.12	

[1] Calculated from the values expressed on the fresh basis.
[2] Values on the fresh basis were estimated by considering 1 gram of dried pepper equivalent to 12 grams of fresh pepper ready for drying.

there could be further loss of ascorbic acid due to solution in the soaking water.

Sweetpotatoes.—Sweetpotatoes of the Porto Rico variety, grown in South Carolina, were used by Mitchell and Lease (*98*) in a study of the stability of carotene in dehydrated sweetpotatoes. The raw sweetpotatoes, containing 170 micrograms of carotene per gram of dry matter, were dehydrated and ground, giving a flour containing 158 micrograms of carotene per gram of dry matter. This represented approximately a 7-percent loss of carotene in the process of dehydration. The raw sweetpotatoes stored at room temperature in loosely stoppered bottles for a period of 4 months showed a loss of 9 to 24 percent of their carotene content, while the flour stored under the same conditions lost nearly all of its carotene. The stability of the carotene in the sweetpotato flour was greatly affected by the method of storage, however, since samples hermetically sealed in cans under CO_2, or under N_2 or a vacuum, showed carotene losses of 17 to 24 percent. These results are summarized in tables 28 and 29. Crude cottonseed oil was found to have a definite preservative effect on the carotene of sweetpotato flour, as evidenced by the fact that after 4 months untreated flour stored at room temperature contained only 32 micrograms of carotene per gram of material, whereas that treated with cottonseed oil contained 92 micrograms per gram.

TABLE 28.—*Carotene losses in dehydration and in storage of sweetpotatoes*

Nature of sample	Carotene				
	Content per gram dry matter		Loss		
	Initial	After 4 months in air at room temperature	In dehydration	In storage	Total from raw potato to stored flour
	μg.	*μg.*	*Pct.*	*Pct.*	*Pct.*
Raw sweetpotatoes	170	154		9.4	
		129		24.1	
Sweetpotato flour	158	8.8	7.1	94.4	94.8

TABLE 29.—*Stability of carotene in sweetpotato flour, as affected by method of storage*

Method of packing	Carotene content per gram of dry matter after various storage periods				Carotene loss during 1 year
	Initial	4 months	8 months	12 months	
	μg.	*μg.*	*μg.*	*μg.*	*Pct.*
In hermetically sealed cans—					
Under CO_2	158	119.0	119.0	131.0	17.1
Under N_2	158	119.0	128.0	119.0	24.0
In vacuum (15 mm.)	158		123.0	119.0	24.0
In air	158		17.3	17.4	89.0
In loosely stoppered bottle	158	8.8	5.4	2.4	98.5

The considerable losses of carotene reported by Mitchell and Lease in the storage of dehydrated sweetpotatoes are explained by Miller [6] as

[6] Private communication from J. C. Miller, Louisiana Agricultural Experiment Station.

due to failure to inactivate enzymes by blanching before dehydration and to grinding of the dehydrated material before placing it in cans. Preliminary unpublished work by Miller at the Louisiana station on dehydration of blanched sweetpotatoes showed that there were certain losses of carotene in the process but good retention of the vitamin upon storage of the dried product if its moisture content was held below 10 percent.

Eggs.—Paired samples of fresh liquid homogenized eggs and dehydrated eggs collected by Hauge and Zscheile (*64*) at an Indiana commercial plant which employed a spray drier were subjected to spectroscopic observations, and to biological assays for vitamin A. The results indicated that little or no loss of vitamin A took place during dehydration. Both the fresh and the dehydrated eggs, according to the biological assay, contained about 44 International Units of vitamin A per gram on the moisture-free basis. Losses during storage of both liquid and dried eggs at —18° C. for 14 weeks were no greater than those caused by drying.

BRINING AND SALTING

Because of the limited use of salt as a preservative of vegetables only a small amount of work has been done to determine the effect of this process upon the vitamins in food thus preserved. Several investigations, however, have dealt with vitamin losses in a few vegetables subjected to brining or salting. These include studies by the Michigan station reported by Camillo et al. (*22*) and Blum and Fabian (*13*), and cooperative work by the United States Department of Agriculture and the North Carolina station reported by Etchells and Jones (*53*).

The results of these studies showed, in general, that vitamin losses after several months' (4 to 10) storage in brine were the greater the lower the salt concentration, except that acidified low-salt brines reduced vitamin losses; that losses from blanched vegetables were greater than from those not blanched; that ascorbic acid losses were much greater than carotene losses; and that freshening of the brined vegetables caused still further losses of carotene and ascorbic acid. Observations with regard to the particular vegetables gave tentative indication of the magnitude of the vitamin changes.

Beans, snap.—Whole or cut snap beans preserved in brine of several concentrations usually lost considerably more than 50 percent of their carotene and practically all of their ascorbic acid. When beans were preserved in a low-salt brine acidified with vinegar, the vitamin losses were reduced, so that from 90 to 95 percent of the carotene and from 10 to 15 percent of the ascorbic acid were retained. Dry-salted compressed lots of blanched green beans put up with 2.5 to 15 percent of salt by weight and held 2 months at room or refrigerator temperatures retained about 60 percent of their carotene and 15 percent of their ascorbic acid.

Beans, lima.—Lima beans preserved without shelling in brines of several concentrations showed variable changes in carotene content, ranging from +9 to —50 percent.

Carrots.—Preservation of carrots in low-salt (2 to 6 percent) brines with or without acidification resulted in no loss of carotene in 2 to 3 months' storage.

TABLE 30.—*Effect of canning on vitamin content of green snap beans*
[Bountiful variety, grown at Amherst, Mass.]

Product	Moisture	Vitamin content per 100 grams														
		Thiamine[1]					Riboflavin[2]					Ascorbic acid[3]				
		Raw or newly canned beans			After 1 year's storage at 38° F.		Raw or newly canned beans			After 1 year's storage at 38° F.		Raw or newly canned beans			After 1 year's storage at 38° F.	
		Wet basis	Moisture-free basis	Loss	Moisture-free basis	Loss	Wet basis	Moisture-free basis	Loss	Moisture-free basis	Loss	Wet basis	Moisture-free basis	Loss	Moisture-free basis	Loss
	Pct.	*μg.*	*μg.*	*Pct.*	*μg.*	*Pct.*	*μg.*	*μg.*	*Pct.*	*μg.*	*Pct.*	*Mg.*	*Mg.*	*Pct.*	*Mg.*	*Pct.*
Fresh raw beans	90.6	63	669				132	1,404				26.5	283			
Blanched, canned in tin can	93.2	54	825	17	558	44	132	1,940	3	1,821	9	4.5	71	75	68	76
Blanched, packed in glass at pH 5.3	93.2	54	822	17	549	45	[4] 84	1,953	2	1,857	7.5	4.3	63	78	60	79
Blanched, glass-packed; acidified to pH 4.2	93.2	60	897	10	627	35	[4] 84	1,953	2	1,941	3	5.0	74	74	71	75
Blanched, glass-packed, head space 1½ inches	93.2	54	819	18	618	38	[5] 87	1,971	2	1,854	8	4.0	59	79	57	80

[1] Thiamine determined by rat-growth method of Booher and Hartzler (*15*).
[2] Riboflavin determined by rat-growth method of Bourquin and Sherman (*16*).
[3] Ascorbic acid determined by procedure of Mack and Tressler (*89*).
[4] Moisture content of this sample 95.7 percent.
[5] Moisture content 95.6 percent.

Corn.—Variable changes, from about +4 to −31 percent, were observed in the carotene content of corn held for 6 months in brines of different concentrations. Still greater changes, from about −45 to −60 percent, were observed in the ascorbic acid content.

Cucumbers.—Cucumbers processed in various concentrations of salt in the manufacture of pickles showed an apparent increase in carotene content, but a decrease in thiamine, riboflavin, and ascorbic acid. Decreases in the content of these water-soluble vitamins ranged from about 50 to 85 percent for salt stock, and from 33 to 87 percent for genuine dill pickles. The influence of the salt is indicated by comparison with the smaller losses, ranging from 12 to 40 percent, for the unsalted types of pickles.

Greens.—Low-salt acidified brine treatment for leafy vegetables (kale, mustard greens, spinach, and turnip greens) caused approximately a 50 percent reduction in carotene values after 4 months' storage.

Peas.—In certain trials green peas were found to retain about 50 percent of their carotene after 4 months' storage in brines of several concentrations. In other tests, however, the retentions were higher, as indicated by changes in carotene values, ranging from about +2 to −20 percent. Changes in ascorbic acid values, ranging from −40 to −80 percent, showed that there were large losses of this vitamin.

CANNING

Canning is so well established as a satisfactory method for home and commercial preservation of foods that large quantities of food are consumed in the canned state. Information on the vitamin value of these products as compared with that of the corresponding fresh foods is, therefore, of particular interest in evaluating the nutritive content of diets in many American homes.

Beans, snap.—As part of a study of the influence of processing on the vitamin content of green snap beans, Farrell and Fellers (*56*) determined their thiamine, riboflavin, and ascorbic acid contents while fresh and raw, after canning, and after storage of the canned products for 12 months at 38° F. in a dark room. Only fresh young beans from 15 to 20 days old (from time of blossoming) were used. After a 2-minute blanch in boiling water they were packed in cans or jars with hot water (175° F.) and processed at 240° F. for 20 minutes, and then cooled in cold water. The beans were canned in glass jars and in plain tin cans, the former at both the normal pH of about 5.5 and also the lower pH of 4.3 attained by acidification with citric acid. The analytical data obtained are summarized in table 30. From these data, it is apparent that canning at the normal pH resulted in about a 17-percent loss in thiamine, a small loss (less than 10 percent) in riboflavin, but a pronounced loss (about 75 percent) in ascorbic acid. In storage, the thiamine loss increased to about 45 percent, but there was no appreciable change in either the riboflavin or ascorbic acid content. The type of container, whether tin or glass, had no appreciable effect on vitamin retention either in the canning process or in subsequent storage. Acidification of the beans was of doubtful value except possibly in the case of thiamine retention.

In the canning, 250 grams of beans and 200 grams of water were used in each glass jar, and 275 and 210 grams of beans and water, respectively, in each can. Thirty days after canning, separate analyses were made of the drained solids and the liquid contents of several samples from each pack. The tests showed that about 50 percent of the ascorbic acid, on an average, and 30 percent of the thiamine and riboflavin of the canned beans were found in the liquid portion. It is clear that the liquid portion of canned vegetables should be utilized in order to obtain the full nutritive value of the food.

In the Wyoming study (*164*) referred to earlier in connection with storage losses in green snap beans, it was found that canned young and immature beans were more palatable and higher in ascorbic acid than were canned mature beans. In canning, the blanching and parboiling processes caused a considerable loss of ascorbic acid, although the beans were more palatable than when these steps were omitted. Canned snap beans held for 3 years lost 73 percent of their ascorbic acid.

Tomato juice.—Conflicting reports regarding the relative degree of retention of ascorbic acid in tomato juice processed in glass and in tin led to an investigation by Reynolds, as reported by the Arkansas station (*3*), of the effects of processing on tomato juice. The results of the experiments showed that ascorbic acid loss during juice preparation varied from 10 to 15 percent. Processing in glass containers caused an additional loss of 8 percent, and storage for 60 days a further loss of 7 percent. The processing and storage losses of tinned juice were only 3 and 1 percent, respectively. Thus, greater losses were incurred in glass-processed juice; after 60 days of storage it retained only 70 to 75 percent of the ascorbic acid originally present in the tomatoes, compared with a retention of 80 to 86 percent in juice processed in tin. Only slight additional losses were observed during longer storage periods. The protective action of the metal container was explained as probably due to its ability to combine with the enclosed oxygen and render it inactive.

The harmful effect of enclosed oxygen was demonstrated in tests in which the fill of container was varied. Completely filled containers favored ascorbic acid retention, while losses increased rapidly as the volume of air space left in the container was increased. In glass containers 75 to 80 percent filled there was a 20- to 25-percent loss during processing and a total loss of 75 to 80 percent after 60 days. In tin containers the corresponding losses of ascorbic acid were from 11 to 12 percent and 12 to 14 percent.

Additional tests showed that in holding prepared tomato juices prior to processing, ascorbic acid loss was relatively low. Juice allowed to stand for 6 hours at room temperature lost less than 3 percent of its ascorbic acid content. If the juice had previously been heated to 180° F., there was no measurable loss of the vitamin during a similar period. Samples processed by heating the juice to 180°, 190°, or 210° F., filling jars, and sealing without further treatment showed no differences in ascorbic acid content.

These results of Reynolds were in general borne out by those obtained by Hauck (*63*) (New York (Cornell)), who observed that home-canned tomato juice (packed hot and processed for 5 minutes in a boiling water bath) canned in tin retained more of its ascorbic acid than did that canned in glass, judging from the higher indophenol-reducing

capacity of the tin-canned juice. Little difference was found between the tin- and glass-packed juices analyzed 2 or 3 days after canning, but the difference was marked in samples stored for from 2½ to 8½ months. Tests with samples packed with and without head space and held in the light and in the dark indicated that neither the amount of head space in glass and tin containers nor protection from light by the tin can accounted for this difference. Contact with the metal seemed to be the most important factor concerned, since juices containing from 18 to 21 milligrams of ascorbic acid per 100 cubic centimeters at canning contained after 8½ months only from 6 to 14 milligrams per 100 cubic centimeters if packed in glass or in enamel-lined tin as compared with 16 milligrams or more if packed in tin. In this study by Hauck it was shown also that cold expression of the juice from the tomatoes, with or without previous heating of the pulp, resulted in no better preservation of ascorbic acid in the home-canned juice than did expressing the juice from the hot pulp.

Grapefruit juice.—Samples of canned grapefruit juice, prepared under various conditions of large-scale processing and obtained with the cooperation of citrus-fruit canners of the Rio Grande Valley, were analyzed for ascorbic acid by Floyd and Fraps (*59*). Comparison of these samples with comparable, although not paired, samples of the fresh juice indicated what influence canning processes had on the ascorbic acid content of grapefruit juice. Twenty-one samples of fresh, raw juice from first-grade, tree-ripened grapefruit contained an average of 41.2 milligrams of ascorbic acid, with a minimum of 38.3 and a maximum of 46.4 milligrams per 100 grams. The 109 samples of canned grapefruit juice tested averaged 33.7 milligrams of ascorbic acid (range, 26.3 to 39.3), this being 18.2 percent lower than the value for the fresh juice. Various practices likely to occur at times in the commercial can-

TABLE 31.—*Influence of various factors on the ascorbic acid content of canned grapefruit juice*

Nature of sample	Ascorbic acid per 100 grams		Average difference in ascorbic acid of canned juice compared with fresh juice[1]
	Range	Average	
	Mg.	*Mg.*	*Pct.*
Fresh raw juice:			
From first-grade tree-ripened fruit	38.3–46.4	41.2	----------
Canned juice:			
Kept standing between extraction and pasteurization for—			
3.5 minutes or less	37.6–39.3	38.5	6.6
5 minutes	35.8–37.0	36.6	11.2
20 minutes	28.0–30.7	29.0	29.6
30 minutes	26.3–27.5	26.9	34.7
Prepared from freshly harvested fruit containing—			
10 percent or less of culls	35.0–37.0	36.1	12.4
90 percent of culls	27.8–31.4	29.5	28.4
Prepared from fruits gathered—			
Before subfreezing weather	35.1–37.0	36.0	12.6
After subfreezing weather	30.3–32.0	31.1	24.8
Separated from fruit solids by—			
Screw (pressing)	29.5–35.9	33.2	19.4
Burr (hand reaming)	30.4–36.4	33.7	18.2
Corrugated rollers (automatic)	32.5–37.3	35.7	13.3
Rotary grater (mechanical)	34.5–37.4	36.4	11.7

[1]All juices were from grapefruit from the Rio Grande Valley, Tex. The fresh raw juices, analyzed as control samples, were comparable in origin with the canned juices, but were not paired with them. The canned juices were prepared under conditions of large-scale processing.

ning procedure were found to influence the ascorbic acid of the canned product. Failure to pasteurize immediately after extraction permitted some destruction of the ascorbic acid, the reduction in value as compared with the average value for comparable samples of the fresh juice varying from 7 percent in juices that had stood 3½ minutes before pasteurization to 35 percent in those that had stood as long as 30 minutes. Increase in the percentage of packing-house culls in the fruit used in a given run or the use of fruit that had been subjected to subfreezing weather before picking, brought about reductions in the ascorbic acid content of the canned product. The various types of extractors used also appeared to exert some influence on the ascorbic acid content of the juice. The data supporting these conclusions are given in table 31.

Strawberries.—The effect of preservation by heat on the ascorbic acid content of strawberries was investigated as one phase of the work on this fruit by Mayfield and Richardson (*94*). Both the Dunlap and Gem varieties were canned, with 1½ cups (300 grams) of sugar to each quart and a half (760 grams) of berries. These were brought slowly to a boil, allowed to stand overnight in a covered kettle, reheated to boiling on the following day, packed hot into pint jars, which were sealed and processed for 9 minutes in a hot-water bath. With each variety the canning process in itself caused a loss of about 50 percent of the original vitamin content (table 32). Storage for 9 months increased this loss to about 80 percent. At the same time, the usual changes in color and flavor occurred.

TABLE 32.—*Effect of canning and subsequent storage on ascorbic acid content of strawberries*

Variety and length of storage period of canned strawberries[1]	Ascorbic acid	
	Content per 100 grams of canned strawberries	Loss
	Mg.	*Pct.*
Dunlap:[2]		
Stored 1–14 days	25	48
Stored 3 months	18	63
Stored 6 months	17	66
Stored 9 months	9	81
Gem:[3]		
Stored 1–14 days	26	50
Stored 3 months	18	64
Stored 6 months	14	72
Stored 9 months	10	80

[1] In canning, 300 grams of sugar, but no added water, was used for each 760 grams of berries.
[2] The fresh berries contained 64 milligrams ascorbic acid per 100 grams.
[3] The fresh berries contained 67 milligrams ascorbic acid per 100 grams.

When the strawberries were made into preserves or jam, using a 1 : 1 ratio of fruit to sugar, the initial ascorbic acid loss ranged from 27 to 46 percent; with a 3 : 2 ratio of sugar to berries and the use of pectin the loss was about 18 percent. All of these products showed progressive losses of the vitamin upon storage, about 50 to 75 percent being lost in 6 months, with but small additional losses up to periods of 9 and 15 months. In the making of strawberry jelly, 36 to 41 percent of the ascorbic acid of the berries was destroyed during extraction of the juice.

Since the pulp was discarded, still more ascorbic acid was lost, and further losses occurred in the process of cooking to the jell stage. As freshly prepared, the jelly contained only about 35 percent of the ascorbic acid originally present in the berries, and after storage for 9 months only about 10 to 15 percent remained.

COOKING

The findings discussed in the following paragraphs suggest that there is room for improvement in cooking practices if the vitamin values of foods are to be conserved and indicate that proper cooking methods permit retention of a large proportion of the original food values. The investigations of cooking losses discussed below concern the various types of products—fresh, frozen, canned, and dehydrated—commonly used.

Broccoli, brussels sprouts, etc.—The effect of different cooking methods on the ascorbic acid content of quick-frozen broccoli was studied by Barnes et al. (*5*), who utilized samples from a regular commercial pack of known history. Ascorbic acid in the frozen broccoli

TABLE 33.—*Effect of cooking on ascorbic acid content of quick-frozen broccoli*[1]

Cooking method	Ascorbic acid					
	Content per 100 grams			Retention	Solution	Loss
	Frozen broccoli	Cooked broccoli	Cooking water[2]			
	Mg.	*Mg.*	*Mg.*	*Pct.*	*Pct.*	*Pct.*
Boiling (5½ minutes in 500 grams water) in enamel pan:						
Covered	96	61	20	60	30	10
Uncovered	89	55	21	57	32	11
Boiling (5½ minutes in enamel pan) in different amounts of water:						
100 grams	86	76	65	82	10	8
500 grams	89	55	21	57	32	11
1,000 grams	86	48	11	53	37	10
Boiling (in 500 grams water in enamel pan) for different lengths of time:						
2 minutes[3]	89	59	15	64	25	11
5½ minutes	89	55	21	57	32	11
11 minutes[4]	91	55	24	55	33	12
Boiling (5½ minutes in 500 grams water) in pans of different composition:						
Enamel	89	55	21	57	32	11
Aluminum	85	48	20	55	32	13
Pyrex	87	53	20	56	30	14
Stainless steel	89	51	20	54	31	15
Steaming in steamers with—						
Floor perforated	88	80	([5])	79	([5])	[6] 21
Floor not perforated	84	72	46	80	11	9
Cooking, solidly frozen, in pressure saucepan of—						
Aluminum	87	70	49	72	11	17
Stainless steel	89	72	50	72	10	18
Cooking, slightly defrosted, in pressure saucepan:						
Aluminum, Flex-seal	95	81	53	76	12	12
Aluminum alloy, Presto	94	83	55	80	9	11

[1] Ascorbic acid was determined essentially by the method of Bessey and King (*9*) as modified by Mack and Tressler (*89*).

[2] The cooking water contained the vitamin that was in the frost plus that leached from the broccoli.

[3] Undercooked; very firm and green.

[4] Overdone; mushy, brown, and with undesirable color and flavor.

[5] The melted frost and condensed steam dripped into the lower compartment of the steamer. There was no liquid present with the vegetable after cooking.

[6] This figure includes loss to solution, as well as destruction.

averaged 88 milligrams per 100 grams, while the 10 to 30 grams of frost that separated in each package contained ascorbic acid in concentrations varying from 18 to 30 milligrams per 100 grams. Cooking in a pressure saucepan or steaming necessitated a preliminary partial defrosting of the broccoli in order to obtain a uniformly done cooked product. This partial defrosting, accomplished by allowing the vegetable to stand at room temperature for an hour and 15 minutes or in the refrigerator at 40° F. for 4 hours, caused no destruction of the ascorbic acid. When the broccoli was defrosted at 40° for 16 hours, however, 6 percent of the vitamin was lost.

Data presented in table 33 show that with one or two exceptions the cooking, by the methods employed, resulted in the destruction of not more than 15 percent of the ascorbic acid originally present in the frozen broccoli. Some of the vitamin—from 9 to 37 percent—was dissolved in the cooking water, however. Neither the amount of the vitamin destroyed nor the amount dissolved was influenced by the composition of the cooking pan, and in the boiling tests little difference resulted by having the pan covered or uncovered. Increasing the amount of water used in boiling the vegetable increased the amount of the vitamin that went into solution but had little effect on the amount destroyed. Slight overcooking in boiling broccoli did not cause increased solution or destruction of the vitamin, but overcooking in the pressure saucepan even for ½ minute resulted in a dark unpalatable cooked product.

After accounting for the ascorbic acid dissolved and that destroyed, the amount of the vitamin retained in the cooked broccoli ranged from 53 to 82 percent of that present in the original frozen product. Broccoli cooked in a standard pressure cooker retained 58 percent of its ascorbic acid but was not an acceptable product. About 80 percent of the vitamin was retained in the steamed broccoli and in the slightly defrosted samples cooked in a pressure saucepan. With the latter method precautions had to be taken to insure a short cooking period in order to obtain an acceptable product of this sulfur-containing vegetable; in the steaming it was necessary to use a steamer with perforated floor in order to obtain a uniformly cooked sample retaining its green color. Boiling did not present these difficulties; by using a loosely covered pan and a very small amount of water it was possible to obtain a cooked product retaining the green color, a pleasing flavor and odor, and 82 percent of the original vitamin. Ten percent of the vitamin was in the cooking water, which because of its small volume could easily be used; only 8 percent of the vitamin was lost.

Whereas the quick-frozen broccoli used in this study had been held in storage at 0° to —10° F. for as long as 5 months without any loss of ascorbic acid, boiled broccoli stored in a covered dish in a mechanical refrigerator at 40° F. lost 19 percent of its ascorbic acid in 24 hours and 34 percent on standing for 48 hours.

Results obtained in this study are in agreement with those of McIntosh et al. (*88*), who, working with quick-frozen brussels sprouts, cauliflower, lima beans, peas, and spinach, found that as the volume of cooking water was increased there was progressively more ascorbic acid in the cooking water and less in the vegetable itself. In these tests also, the composition of the cooking utensil was found to have very little effect on the ascorbic acid content of the boiled quick-frozen vegetable, and, with few exceptions, the retention was the same whether

covered or uncovered utensils were used. In the several tests, from 12 to 15 percent of the ascorbic acid was leached from brussels sprouts, from 23 to 29 percent from cauliflower, from 20 to 28 percent from peas, from 24 to 28 percent from spinach, and from 31 to 36 percent from lima beans.

Onions.—Experiments by Murphy (*107*) showed that cooking caused a decrease in the ascorbic acid value of onions. Increase in the length of the cooking period resulted in a decrease in the ascorbic acid value of the cooked onions (table 34). Tests with several varieties in which 25 to 30 grams of raw onions were cooked in 150 cubic centimeters of

TABLE 34.—*Influence of cooking time on the ascorbic acid value of onions*

Cooking time (minutes)	Southport Yellow Globe variety			Southport White Globe variety		
	Ascorbic acid			Ascorbic acid		
	Per 100 grams		Decrease	Per 100 grams		Decrease
	Raw	Cooked		Raw	Cooked	
	Mg.	*Mg.*	*Pct.*	*Mg.*	*Mg.*	*Pct.*
10 (overdone)	31	11	65			
5 (tender)	26	15	42			
3 (firm)	27	19	30	16	12	25
1	21	19	10	16	12	25

TABLE 35.—*Effect of cooking on ascorbic acid value of onions*

Variety	Ascorbic acid per 100 grams		Decrease with cooking
	Raw	Cooked	
	Mg.	*Mg.*	*Pct.*
Brigham Yellow Globe	28	24	14
Earliest White Queen	33	26	21
White Sweet Spanish	13	10	23
Silver White Portugal	21	16	24
Yellow Bermuda	12	7	42
Southport Yellow Globe	26	15	42
Average	22	16	27

boiling water for 5 minutes, the time required for onions to become tender, gave ascorbic acid values averaging 27 percent lower than the corresponding values for the raw onions. (See table 35.)

Papayas.—The papaya may be used either green or ripe. The ripe papaya is more desirable when used raw, while the green fruit is usually baked or boiled and served as a vegetable, or stewed and served as a sauce. Miller and Louis in Hawaii (*65*), using the native papayas, observed ascorbic acid losses of 7 and 12 percent in two samples baked at 350° F. for 20 to 25 minutes. A sauce made by simmering papaya with a little sugar for 20 minutes lost 7 percent of the original ascorbic acid.

Parsnips.—Brown and Fenton (*18*) determined the ascorbic acid losses in parsnips, whole and unpeeled, peeled and cut in pieces radially, and peeled and cut crosswise, when cooked by boiling, by steaming, and

TABLE 36.—*Effect of cooking on ascorbic acid content of parsnips*

Cooking method	Ascorbic acid in parsnips (Hollow Crown variety)[1]													
	Whole unpeeled[2]					Pieces[3]					Sliced				
	Content per 100 grams		Retention	Solution	Destruction	Content per 100 grams		Retention	Solution	Destruction	Content per 100 grams		Retention	Solution	Destruction
	Raw	Cooked				Raw	Cooked				Raw	Cooked			
	Mg.	*Mg.*	*Pct.*	*Pct.*	*Pct.*	*Mg.*	*Mg.*	*Pct.*	*Pct.*	*Pct.*	*Mg.*	*Mg.*	*Pct.*	*Pct.*	*Pct.*
Boiling (10 minutes in enamel pan):															
Covered:															
In 500 cubic centimeters salted water						19	16	86	9	5					
Uncovered:															
In 500 cubic centimeters salted water						22	18	81	10	9					
In 750 cubic centimeters salted water						24	20	83	8	9					
Boiling (in 500 cubic centimeters salted water) in enamel pan for different lengths of time:															
15 minutes	20	18	91	5	4										
10 minutes						22	18	81	10	9					
8 minutes											12	10	84	15	1
Boiling (8 minutes in 500 cubic centimeters salted water) in pans of different composition:															
Enamel											12	10	84	15	1
Pyrex											18	15	81	19	0
Stainless steel											17	11	66	10	24
Aluminum											14	10	71	16	13
Steaming (in aluminum steamer with perforated floor):															
25 minutes	17	15	86		14										
20 minutes						20	17	83		17					
Cooking in pressure saucepan (at 15 pounds pressure):															
Flex Seal:															
5 minutes[4]						21	16	78	2	20					
2 minutes[5]						25	23	90	4	6					
1 minute[6]						20	19	97	2	1					
2 minutes											19	16	86	9	5
Presto:															
2 minutes											20	17	83	12	5

[1] Ascorbic acid and dehydroascorbic acid. Determination by method of Bessey and King (*9*) as modified by Mack and Tressler (*89*).
[2] Radial section removed for raw samples.
[3] Peeled, cut crosswise, upper part quartered, lower part halved.
[4] Overdone.
[5] Done.
[6] Underdone.

in two makes of pressure saucepans. The results, summarized in table 36, showed that actual destruction of the vitamin in the several cooking tests ranged from 0 to 24 percent, while from 2 to 19 percent was found in the cooking water. Retention of the vitamin in the parsnips cooked just to doneness by the various methods ranged from 66 to 91 percent. Parsnips boiled whole unpeeled and cooked in pieces in a pressure saucepan showed the best ascorbic acid retentions, 91 and 90 percent, respectively; those steamed whole, unpeeled, or cut in pieces and boiled retained 86 percent of their original ascorbic acid. In both boiling and steaming the whole, unpeeled parsnips retained more ascorbic acid than did those which had been sliced or cut in pieces. Parsnips boiled in enamel and Pyrex pans retained more ascorbic acid than those boiled in stainless steel and aluminum pans, 84 and 81 percent against 66 and 71 percent, respectively. Parsnips cut in pieces and cooked 5 minutes (overdone) in the pressure saucepan retained only 78 percent of the original ascorbic acid, whereas 90 percent was retained at the "done" state after 2 minutes' cooking.

Peas.—Ascorbic acid losses in the cooking of peas were investigated by Todhunter and Robbins (*145*), who employed various samples from paired lots of fresh and frozen peas of the Thomas Laxton and Tall Alderman varieties grown at Puyallup, Wash. Analyses of the peas before and after cooking and of the cooking water gave indication of the nature and the amount of the losses incurred by both the fresh and the frozen samples cooked by the different methods. Data available on the ascorbic acid content of the peas before freezing permitted calculation of the total loss of ascorbic acid as the fresh peas were frozen and finally cooked for serving (table 37).

TABLE 37.—*Ascorbic acid losses in cooking fresh and frozen peas*

Peas and method of cooking	Ascorbic acid[1]						Retention of ascorbic acid, on basis of fresh raw peas
	Content per 100 grams of peas			In cooking liquid	Destroyed in cooking	Retained by peas	
	Before cooking	After cooking	Cooked, calculated to uncooked weight				
	Mg.	*Mg.*	*Mg.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Fresh:[2]							
Boiled in small amount of water[3]	24–26	17–22	15–20	29–35	−8–9	62–77	62–77
Boiled in large amount of water[4]	24–28	15–18	13–16	42–43	0–4	54–57	54–57
Steamed[5]	25–28	22–27	20–24	12–14	0–8	80–86	80–86
Frozen:[6]							
Boiled in small amount of water[3]	17–18	12–15	10–13	18–39	−5–23	59–76	43–49
Boiled in large amount of water[4]	18–19	10–11	9–10	37–39	5–16	47–56	34–41
Steamed[5]	17–23	13–18	11–15	17–22	12–18	64–70	45–55

[1] Ascorbic acid was determined by titration of a 3-percent metaphosphoric acid extract of the peas with 2,6-dichlorobenzenoneindophenol solution.
[2] Fresh peas used immediately after picking and podding were cooked for 8 minutes after the internal temperature reached 99° C.
[3] 350 grams of peas were cooked in 120 cubic centimeters of water in a covered aluminum pan.
[4] 350 grams of peas were cooked in 350 cubic centimeters of water in a covered aluminum pan.
[5] The peas were cooked in a nonleach steamer so constructed that the condensing steam did not fall back over the vegetable.
[6] The peas, while still frozen, were placed in boiling water or in a steamer and cooked for 8 minutes after the internal temperature reached 95.6°C.

Table 37 shows the range of values for ascorbic acid content, retention, and loss. These values indicate that cooking caused little or no destruction of the vitamin in the fresh peas and in certain of the frozen samples, although some of the latter lost as much as 12 to 23 percent. Some of the vitamin, from 12 to 43 percent, was dissolved in the cooking water in the various tests. Peas cooked in a nonleach steamer retained a higher percentage of the original ascorbic acid than those cooked in boiling water. Increasing the amount of the cooking water increased the solubility losses of ascorbic acid. The fresh peas were somewhat higher in ascorbic acid, since they had not undergone the scalding and freezing process, and in cooking they retained from 54 to 86 percent of their vitamin as compared with retentions of 47 to 76 percent in the cooked frozen peas. These retentions in the cooked frozen peas represented from 34 to 55 percent of the ascorbic acid present in the original fresh raw peas.

The observations just noted, to the effect that cooking caused little or no destruction of ascorbic acid in fresh and frozen peas, were paralleled with respect to thiamine losses according to Fincke et al. (*58*), who tested Oregon-grown peas of the Thomas Laxton variety. These peas, cooked in a small amount of water for a short time and assayed by rat-curative or rat-growth procedures, were found to lose not more than about 10 percent of their thiamine in cooking. Since this loss was within the limits of experimental error of the assay method used, it was considered that under the experimental conditions employed, there were no significant differences between fresh and frozen uncooked and cooked peas. In this study the small amount of cooking water was analyzed with the peas so that no estimate was made of the amount of thiamine dissolved or the amount retained by the peas.

Potatoes.—Several practices commonly employed in the home in cooking potatoes were investigated by Richardson and Mayfield (*129*) to determine how these methods compared in conserving the ascorbic acid of the potato during cooking. The potatoes used were of the Netted Gem variety and had been in winter storage in Montana for several months. The ascorbic acid content of the raw and of freshly cooked potatoes was determined by the chemical method, using a photoelectric

TABLE 38.—*Ascorbic acid losses in cooking potatoes*

Materials tested	Tests	Ascorbic acid	
		Content per 100 grams (raw basis)	Loss
	No.	*Mg.*	*Pct.*
Raw potato	14	9.1	
Boiled potato:			
In jackets	20	9.2	0
Pared, cut:			
Not soaked	22	7.4	18.7
Soaked 4 hours in fresh water	24	7.0	23.1
Soaked 4 hours in salt water	26	7.7	15.4
Potato cooked in pressure saucepan:			
Pared, cut:			
Not soaked	20	8.1	10.9
Soaked 4 hours in fresh water	18	7.8	14.3
Soaked 4 hours in salt water	18	8.6	5.5

colorimeter. In order to determine cooking losses, the ascorbic acid content of the cooked potatoes was calculated back to the raw basis, weight changes in soaking and cooking being considered in all calculations. The results presented in table 38 show that the potatoes boiled in their jackets retained practically all of their ascorbic acid, while those that were pared and quartered lost about 19 percent. This loss was increased when the pared quartered potatoes were held in water for several hours previous to cooking, as is a common practice; when the soaking water was salted (2.5 percent salt), however, the boiled potatoes lost less of their vitamin than did comparable lots boiled without any previous soaking. Cooking of the potatoes in a pressure saucepan under steam pressure of 15 pounds caused less destruction of ascorbic acid than boiling in an ordinary kettle. Pared potatoes that had been allowed to stand in salt water previous to cooking retained practically 95 percent of their ascorbic acid when cooked in a pressure saucepan.

Turnip greens.—The Southern cooperative project on the ascorbic acid content of turnip greens, as reported by Reder [7], included a study of the effect of cooking for different periods on the content of this vitamin in fresh and stored greens. The results of this study are summarized in table 39. They show that Shogoin and Seven Top turnip greens which were cooked immediately after harvest or after storage for 24 hours at 40° F. lost from 24.6 to 30.5 percent of their ascorbic acid when cooked for ½ hour, and from 64.4 to 69.3 percent when cooked for 4 hours. Greens stored for 24 hours at room temperature lost a

TABLE 39.—*Effect of cooking on ascorbic acid content of turnip greens* [1]

Variety and storage	Basis	Moisture content	Ascorbic acid				
			Content[2]			Loss in cooking	
			Raw	Cooked for[3]—			
				½ hour	4 hours	½ hour	4 hours
		Pct.	*Mg.*	*Mg.*	*Mg.*	*Pct.*	*Pct.*
Shogoin:[4]							
Not stored	Wet	89.87	139.93	100.24	45.52		
	Moisture-free		13.99	10.19	4.63	27.2	66.9
Stored 24 hours at—							
40° F.	Wet	89.41	139.59	95.35	46.00		
	Moisture-free		13.27	9.22	4.57	30.5	65.6
Room temperature	Wet	88.48	121.17	81.87	31.15		
	Moisture-free		10.55	7.12	2.74	32.5	74.0
Seven Top:[5]							
Not stored	Wet	87.02	148.08	110.06	51.59		
	Moisture-free		11.85	8.94	4.22	24.6	64.4
Stored 24 hours at—							
40° F.	Wet	86.50	149.97	110.28	45.75		
	Moisture-free		11.70	8.69	3.59	25.7	69.3
Room temperature	Wet	84.42	121.68	82.16	29.89		
	Moisture-free		7.95	5.37	1.99	32.5	76.0

[1] Ascorbic acid was determined by the method of Morell (*99*) as modified by Loeffler and Ponting (*85*).
[2] Content on wet basis expressed in milligrams per 100 grams; on moisture-free basis in milligrams per gram.
[3] 50-gram samples in 100 cubic centimeters distilled water were boiled on electric hot plate in beakers covered by condensers. Greens and cooking water were analyzed together.
[4] 80 samples.
[5] 72 samples.

[7] See footnote 5, p. 14.

greater percentage of their ascorbic acid content during cooking than did fresh greens or those stored for 24 hours at 40°. Shogoin and Seven Top greens stored at room temperature lost 32.5 percent of their ascorbic acid content when boiled for ½ hour and 74 and 76 percent, respectively, when boiled for 4 hours.

Vegetables, miscellaneous.—In an exploratory survey of the nicotinic acid content of vegetables and fruits in common use, Russell et al. (*130*), utilizing foods purchased on the open market in New Jersey, analyzed the raw vegetable, and, if ordinarily cooked for the table, the same foods immediately after being cooked. The food was placed in a minimum quantity of boiling water and cooked in the minimum time necessary to make it palatable. Covered aluminum pans were used. Salt was added as seasoning. In keeping with household practice, cooking utensils were not rinsed when the cooked food was removed.

The amount of nicotinic acid lost in cooking was found to vary with the type of food, and frequently with different samples of the same food. Data from this study, as summarized in table 40, show that some of the nicotinic acid was dissolved in the cooking water. The amount extracted ranged from 2 to 41 percent of the quantity

TABLE 40.—*Nicotinic acid losses in cooking fresh vegetables* [1]

Food	Samples	Nicotinic acid [2]					
		Retained in solid portion of cooked food [3]		In cooking water [3]		Destroyed in cooking [3]	
		Range	Average [4]	Range	Average [4]	Range	Average [4]
	No.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Roots and tubers:							
Beets, peeled	3	63.0–67.5	------	15.6–30.2	------	2.3–21.4	------
Carrots, scraped	3	71.7–85.2	------	5.0–12.3	------	9.8–16.0	------
Potatoes, peeled	3	77.0–92.7	------	2.0–19.4	------	3.2–11.4	------
Sweetpotatoes, peeled	3	81.5–94.4	------	[5] 0– 3.7	------	2.3–14.8	------
Summary	12	63.0–94.4	80.2	0–30.2	10.4	2.3–21.4	9.4
Legumes:							
Beans, lima	3	74.7–89.5	------	0–13.3	------	+2.8–20.2	------
Beans, snap	3	52.8–84.3	------	8.1–41.2	------	5.4– 7.6	------
Peas	3	65.5–76.0	------	14.7–32.7	------	1.8–10.3	------
Summary	9	52.8–89.5	76.7	0–41.2	16.4	+2.8–20.2	6.9
Flowers:							
Broccoli	3	58.7–92.5	------	0–12.9	------	7.5–35.2	------
Cauliflower	3	69.8–92.0	------	0–17.5	------	8.0–16.6	------
Summary	6	58.7–92.5	74.9	0–17.5	8.4	7.5–35.2	17.1
Leafy vegetables:							
Beet greens	2	77.0–83.5	------	0–11.2	------	11.8–16.5	------
Cabbage	3	69.7–79.3	------	0– 4.1	------	20.7–26.2	------
Spinach	3	63.3–74.5	------	0– 5.6	------	20.4–36.7	------
Summary	8	63.3–83.5	74.9	0–11.2	2.6	11.8–36.7	22.5
Shoots:							
Asparagus	3	81.2–91.9	87.2	0– 4.2	1.4	7.4–18.8	11.4

[1] Vegetables were cooked by boiling in a minimum quantity of water until just done.
[2] Nicotinic acid was determined by the microbiological method of Snell and Wright (*139*).
[3] The amounts of the vitamin retained, dissolved, and destroyed were calculated as percentages of the nicotinic acid present in the raw sample.
[4] Average values in summary were computed from analyses reported of the individual samples.
[5] As used in this column, the value 0 indicates that no cooking water remained.

present in the raw food and was usually greater the larger the volume of cooking water. Some of the vitamin was destroyed in the cooking process. As indicated in table 40, these losses averaged about 9 percent for roots and tubers, 7 percent for legumes, 17 percent for flower forms, 22 percent for leafy vegetables, and 11 percent for asparagus shoots. In spite of solution and destruction of some of the nicotinic acid, these foods when cooked still retained significant quantities of the vitamin, averaging about 80 percent for roots and tubers, 87 percent for asparagus, and 75 percent for the legumes, flower forms, and leafy vegetables analyzed.

Dried legumes were soaked in water overnight, the soaking water discarded, and the legumes cooked in fresh water, as is common in household practice. Nicotinic acid was determined in the dry and the cooked beans and peas and in the soaking and cooking water (table 41). If the soaking water was discarded the average loss of nicotinic acid was about 7 percent. Loss due to cooking averaged

TABLE 41.—*Nicotinic acid losses in cooking dried legumes* [1]

Legume and item		Nicotinic acid—			
		In soaking water[2]	Retained in cooked beans[2]	In cooking water[2]	Destroyed in cooking[2]
		Pct.	*Pct.*	*Pct.*	*Pct.*
Beans[3]	Range	2.1–16.3	64.4–88.9	4 0–15.6	8.1–21.0
	Average	6.5	79.8	1.5	12.2
Peas, split[5]	Range	5.2–19.9	70.8–77.3		9.3–17.5
	Average	11.2	74.6	0	14.1

[1] The dried legumes were soaked in water overnight, the cooking water discarded, and the legumes then boiled in a minimum quantity of water for the minimum time necessary to make them palatable.
[2] Average values computed from analyses reported for the individual samples.
[3] Analyses were made of 13 samples of beans, including those designated as black turtle, [red] kidney, lima, navy, and yellow-eyed beans.
[4] As used in this column the value 0 indicates that no cooking water remained.
[5] 3 samples of split peas were analyzed.

13 percent, a value somewhat higher than the 7 percent for fresh legumes, probably because of the longer cooking time. Although the dry lima beans and peas contained a higher percentage of nicotinic acid than the fresh, the potency of the cooked solid portion of the latter was considerably greater than that of the cooked dried products. This was due possibly to the difference in maturity at the time of harvest. In canned green beans, lima beans, and peas 30 to 40 percent of the nicotinic acid content was found in the liquid portion. When the canned beans were heated in this liquor and brought just to the boiling point in a covered pan, as though in preparation for serving, the loss of nicotinic acid ranged from 2 to 10 percent.

Meats.—The retention of thiamine, riboflavin, and nicotinic acid in pork hams and loins cooked by standard procedures was studied by McIntire et al. (*86*) (Wisconsin). The loins and hams, obtained from the same hogs, were prepared leaving about one-half inch of fat on the outer surface. Seven different series of samples were analyzed, the loin cuts after being roasted, braised, or broiled, and the ham cuts after roasting or broiling. Corresponding cuts from the opposite hams or loins were analyzed in the raw state. From the data obtained,

vitamin retentions were estimated for the cooked meat alone, and for the cooked meat and drippings.

Data presented for four series of analyses are summarized in table 42, together with average retention figures estimated by the authors from the study as a whole. They point out that the method of cooking and size of the cut have an effect on the percentage retention of the vitamins in the meat and a corresponding effect on the amount of each vitamin in the drippings. Appreciable amounts of the vitamins were found in the drippings, particularly from braised loin cuts. This might have been due to the larger surface exposed and to the extracting effect of the condensing steam in the pan. Broiling of similar cuts resulted in smaller losses in the drippings than was the case in braising. The total retention in the meat plus the drippings was about the same for all the methods of cooking, averaging about 70 percent for thiamine and at least 90 percent for riboflavin and nicotinic acid. The average

TABLE 42.—*Retention of vitamins in pork after cooking* [1]

	Roasting			Braising			Broiling		
	Loin[2]	Ham[2]	General average	Loin[2]	Ham	General average	Loin[3]	Ham[3]	General average
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Thiamine retained in—									
Meat alone	68	68	70	50	------	50	67	72	70
Meat and drippings	71	72	70	68	------	70	71	79	70
Riboflavin retained in—									
Meat alone	90	82	85	77	------	85	82	82	85
Meat and drippings	96	88	90+	95	------	90+	93	90	90+
Nicotinic acid retained in—									
Meat alone	79	90	85	65	------	65	80	82	85
Meat and drippings	86	99	90+	93	------	90+	89	95	90+

[1] Vitamin retention in the meat alone was estimated by dividing the total milligrams of the vitamin in the entire piece of cooked meat by the total milligrams in the uncooked meat; retention in the meat and drippings was calculated by adding the milligrams of vitamin in the drippings and the fresh cooked meat and dividing the sum by the total milligrams in the uncooked meat.

[2] 4 samples.

[3] 3 samples.

retention in the meat alone was 70 percent for thiamine after roasting and broiling, and 50 percent after braising; 85 percent for nicotinic acid after roasting and broiling, and 65 percent after braising; and 85 percent of riboflavin as a result of any of the cooking methods.

In an exploratory investigation of the pantothenic acid content of meats, Waisman et al. (*151*) (Wisconsin) utilized meats which had been trimmed of most of the surface fat before analysis and which, in the cooking tests, were not cooked by standardized procedures. The cooking losses observed were considered, therefore, as only roughly approximate. Taken with this reservation, they suggested a decrease of 30 to 40 percent in pantothenic acid content of meats after cooking or commercial processing.

MILLING

The vitamins of cereal grains are largely concentrated in the outer layers, which include the bran and the germ portions. In the milling process these outer layers are removed, which leaves the highly milled flours with a greatly reduced vitamin content as compared with that

of the whole grain. The present program of flour enrichment is aimed at restoring, at least in part, the vitamins and minerals removed from the wheat berry in milling. Recent studies, dealing with the distribution of the B vitamins in wheat and rice, indicate the extent of the milling losses and the content of vitamins in the milling products and byproducts.

Wheat.—Fifty-five samples of wheat, varying as to variety and source, were assayed by Teply et al. (*143*) for their content of nicotinic acid, pantothenic acid, and pyridoxine. Samples of wheat germ and of commercially milled patent and clear flours were also assayed for these vitamins. The results, summarized in table 43, indicate that patent flour, compared with whole wheat, contains approximately one-sixth as much nicotinic acid and about one-half as much pantothenic acid and pyridoxine. Since so much nicotinic acid is lost, the addition of this vitamin as well as thiamine (as is the practice in flour enrichment) is necessary in order to restore to patent flour the vitamin balance of whole wheat. It is interesting to note that pantothenic acid

TABLE 43.—*Nicotinic acid, pantothenic acid, and pyridoxine in wheat flours and wheat germ*

Sample	Nicotinic acid		Pantothenic acid		Pyridoxine	
	Content per 100 grams	Decrease in value with milling	Content per 100 grams	Decrease in value with milling	Content per 100 grams	Decrease in value with milling
	μg.	*Pct.*	*μg.*	*Pct.*	*μg.*	*Pct.*
Whole wheat (average of 55 samples)	59		13.3		4.6	
Patent flour	10	83	5.7	57	2.2	52
First clear flour	21	64	9.6	28	3.9	15
Second clear flour	57	3	12.8	4	5.7	
Wheat germ	34		15.3		9.6	

and niacin are not concentrated in the wheat germ as are thiamine, riboflavin, and pyridoxine, but instead are apparently concentrated in the bran.

Rice.—Thiamine in products of commercial rice milling was determined by Kik (*72*), who employed samples from four varieties grown in Arkansas and one grown in Louisiana. The data presented in table 44 show that rough rice, or paddy, tends to contain slightly less thiamine than the whole brown rice, apparently because of the very low thiamine content of the hulls of the rough rice. These hulls are removed as the first step in the milling process to give the brown rice. This is then milled in successive steps, the first two of which remove the outer bran layers (first- and second-break bran) and the germ, while the third and fourth steps remove the inner bran layers (cone and brush polish). The finished, clean, polished rice sold for human consumption is known as head rice. If the kernels are somewhat broken, the product is sold as second head rice. The data indicate that the rice bran and rice germ are excellent sources of thiamine and that their removal in the milling process causes a loss of about 80 percent of the thiamine of the brown rice.

Because large vitamin losses result from the usual milling of rice, a process designed to retain more of the original vitamin after milling

TABLE 44.—*Thiamine content* [1] *per gram of products of commercial rice milling*

Products	Variety				
	Supreme Blue Rose	Early Prolific	Fortuna	Lady Wright	Improved Blue Rose
	μg.	μg.	μg.	μg.	μg.
Paddy, or rough rice	2.80	3.02	2.79	3.00	3.07
Whole brown rice	2.80	3.25	3.05	3.00	3.00
Finished, clean, polished rice:					
Head rice	.64	.62	.54	.49	.63
Second head rice	.48	.52	.47	.46	.58
Rice byproducts:					
Hulls	1.04	1.23	.93	1.33	1.00
Bran:					
First-break	33.30	28.05	21.50	26.60	20.50
Second-break	20.50	18.30	11.80	17.60	18.00
Polish:					
Pearling cone	26.10	20.70	(2)	(2)	20.80
Brush	27.30	20.65	15.00	19.40	16.40

[1] Total thiamine determined by an adaptation of the procedure of Hennessy and Cerecedo (*67*).
[2] Pearling cones are not used on long-grain varieties.

was investigated. This process, described briefly by Kik *(71)*, involves cleaning of the rough rice by vacuum, treating it with hot water under pressure, then exposing it to steam, drying, and milling. Because of its solubility, the thiamine dissolves in the water which permeates the kernel under pressure and is largely carried into the endosperm, where it is retained as the bran layers are subsequently removed in milling. Rice thus converted retains about 70 percent of the thiamine originally present in the unmilled rice. The samples of dried converted rice analyzed contained from 1.35 to 1.74 micrograms of thiamine per gram. Among other members of the vitamin B complex in rice, 78 percent of the riboflavin and from 60 to 80 percent of the nicotinic acid were found to be retained by the converted rice. Another procedure, that of undermilling (which leaves more of the bran layers on the kernel), served to leave about twice as much of the thiamine in the finished product as was left under ordinary milling. The undermilled rice contained 1.22 and 0.92 micrograms of thiamine per gram as compared with 0.57 and 0.65 microgram in the samples of ordinary milled rice.

SUMMARY OF INVESTIGATIONS OF FACTORS AFFECTING VITAMIN VALUES OF FOODS

The experimental findings discussed in the preceding pages offer additional evidence that the vitamin value of a food as served may vary measurably from one meal to the next. The results go further in showing what factors cause this variation and in suggesting points to be considered in getting the most of the vitamin value that a food can offer.

The results obtained show that several factors contribute to this variation. The first of these is the matter of natural variation, that is, differences existing at the time of harvest, or of slaughter in the case of animal tissues. Next, changes in vitamin values occur in the period of storage between harvest and use. Then come further losses in processing for preservation, as by freezing, canning, and dehydration, and in storage of the processed foods. Finally, additional losses may occur in cooking and in holding the cooked food prior to serving. Infor-

mation on the extent of these changes and suggestions for minimizing them are offered in the following summary tables and notes based on the numerous experiment station researches just discussed in some detail.

A food crop as produced in various parts of the country, as harvested in different seasons from the same garden, or even as picked at one time from different parts of the same field or garden can be expected to show considerable variation in vitamin content. This variation is due in part to the effects exerted by different soils and fertilizer treatments, climatic conditions, and conditions of sun and shade, in brief, to different environmental conditions. Geographical locality in itself is apparently not an influencing factor except insofar as environmental conditions are characteristic of that location. A given environment, moreover, does not necessarily have the same influence on different vitamins or different foods. Another factor influencing the vitamin content of foods of plant origin is that of variety. The controlled experiments gave evidence that differences in vitamin content are often associated with varietal differences but that this effect is often obscured by the much greater variations due to environment. This does not lessen the importance of varietal values, however, for it is obvious that if a variety having low ascorbic acid content, for example, is subjected to adverse environmental influences the resulting food crop may be a very poor source of vitamin C. On the other hand, a high-vitamin variety subjected to the same unfavorable conditions could still contribute materially to vitamin C requirements. Plant breeders and commercial growers would do well, therefore, to consider vitamin values as well as quality standards in the selection of varieties to be grown.

Such effect as environment and variety may have exerted must be accepted, of course, in the food as harvested. Attention can be given, however, to the stage of maturity in the selection of fruits and vegetables for their vitamin value. From the studies that have been considered in this report it appears that many fruits should be used at prime maturity because they offer then not only their best quality but also their greatest vitamin values. Such is the case with strawberries, blueberries, blackberries, cantaloups, honeydew melons, and peaches, all of which increase in ascorbic acid content up to prime maturity. Beyond this prime ripe stage the cantaloups and honeydew melons lose some of their ascorbic acid content. Among the vegetables noted, fruit forms such as tomatoes and peppers likewise increase in ascorbic acid content as they ripen, and peppers also increase manyfold in carotene value. This increase in vitamin value with increasing maturity is not characteristic of all fruits and vegetables, however, as is illustrated by mangoes, which are richer in ascorbic acid when green than when ripe, and by onions and beans, which show the highest vitamin values in the young, immature state.

Once harvested, fruits and vegetables are subject to vitamin losses while they are being shipped, while they are held in the market, and while they are held in the home until prepared for table use. The experiments discussed in an earlier section of this report have dealt chiefly with ascorbic acid losses. The results of these studies, summarized in table 45, indicate that the losses may be small or large, depending on storage time and conditions and the commodity con-

TABLE 45.—*Ascorbic acid losses of vegetables and fruits in common storage*

Crop	Storage conditions	Storage period	Ascorbic acid loss	Station
Vegetables:				
Beans, snap	In electric refrigerator	48 hours	60 percent	Wyoming
Cabbage	At 32° F.		Little	Maine
	In electric refrigerator	1 week	50 percent	Do.
Onions	Harvested in October and put in dry storage in cool attic	1 month	20 percent	Do.
		2 months	36 percent	Do.
		3 months	45 percent	Do.
Parsnips	Dug in November; held at 34°–35° F. and 95 percent relative humidity.	Nov., Dec., Jan., Mar., Apr.	Little 50–60 percent	New York (Cornell) Do.
Peas	Held in pod at room temperature	8–16–18 hours	Little	New York State, Washington
		24 hours	10 percent	Washington
	Shelled and held at room temperature	24 hours	21 percent	Do.
Potatoes		Dec.–May	46–57 percent	Wyoming
Turnip greens	Stored at harvest at 40° F.	24 hours	4–6 percent	Southern Cooperative
	Stored at room temperature	24 hours	22–32 percent	Do.
Fruits:				
Apples	Stored at 32° F.	2 months	12–47 percent	West Virginia
Blackberries, dewberries, and raspberries	Sound berries held at 41° F.	2 days	Little or none	North Carolina
		3 days	50–80 percent	Do.
Blueberries	Sound berries held at 41° or 77° F.	4 days	Little or none	Do.
		6 days	50 percent	Do.
Strawberries	Sound berries held at 41° F.	2–3 days	Little or none	North Carolina, Montana
	Sound berries in refrigerator hydrator	5 days	Little or none	Montana
	Sound berries at 77° or 104° F.	2 days	Slight	North Carolina, Montana
	Bruised berries, held at 77° F.	2 days	About 90 percent	Do.
		3 days	Almost 100 percent	Do.
	Sliced; held at room temperature	30 minutes	None	Montana

cerned. Under the same storage conditions, for example, acid fruits, such as strawberries, seem to retain their ascorbic acid much better than do nonacid vegetables. Perishable vegetables, such as beans, peas, cabbage, and turnip greens, may lose appreciable amounts of their ascorbic acid even in a day. If they are held longer than this it seems reasonable to expect that ascorbic acid losses would be very large, especially if the vegetables are held in the market or in the home at room temperature. Loss of thiamine under these conditions, judging from the observations on peas, would be much lower than that of ascorbic acid, however. Peas, it may be noted, lose their ascorbic acid much less rapidly if held in the pod than if held as shelled peas. Holding the perishable vegetables at refrigerator temperature, about 40° F., retards but does not prevent ascorbic acid loss. If such vegetables are held for several days even in the refrigerator, losses may be large, as was noted in snap beans, which lost 60 percent of their ascorbic acid in the refrigerator, and in cabbage, which lost 50 percent in a week. Still lower temperatures, around 32°, such as those used in commercial refrigerated warehouses, apparently serve better to retard ascorbic acid losses, if the results reported for cabbage are representative.

Berries, if eaten in the fresh state, must be utilized within a few days of harvest. Fortunately, they are good sources of ascorbic acid and appear to retain the vitamin fairly well even in shipping and marketing. Proper storage conditions facilitate the vitamin retention. If free from injury when picked and if shipped under good conditions, that is, under refrigeration and without bruising, berries do not lose an appreciable amount of their ascorbic acid in 48 to 72 hours. Even if they are held at room temperature under market conditions for 1 or 2 days there is little loss of the vitamin. In the household refrigerator sound berries can apparently be held for as long as 5 days with little or no vitamin loss. In all cases they should be held without capping and with care to prevent bruising and crushing, for the ascorbic acid in injured berries disappears in a day or two. In preparation for the table it is desirable, in the case of strawberries at least, to cap them after washing, not before, in order to retain the maximum of their ascorbic acid. When preparing strawberries for certain table uses, as for shortcake for example, it is preferable to slice them rather than crush them and to sugar the sliced berries if they are to be held. If it is necessary to hold the sliced berries longer than half an hour before serving, they should be kept in the refrigerator.

These various examples of the vitamin losses that occur in holding perishable fruits and vegetables for even a few days after harvest serve to emphasize the importance of the home garden in supplying strictly fresh foods.

Storage crops, such as the onions, parsnips, and potatoes considered here, lose ascorbic acid throughout the storage period, this loss becoming more pronounced in the late winter and early spring months. Diets in which stored vegetables are used should be planned with a view to compensating for these vitamin losses.

Apples, among the fruits considered, are also held in winter storage. Although they are not a rich source of ascorbic acid to begin with, they make but very small contribution of this factor after a month or two of storage.

TABLE 46.—*Vitamin losses in freezing and freezing storage of fruits and vegetables*

Frozen product and procedure used	Loss in freezing				Total loss after freezing storage[1]				Storage period	Station
	Vitamin A	Thiamine	Ribo-flavin	Ascorbic acid	Vitamin A	Thiamine	Ribo-flavin	Ascorbic acid		
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Mo.*	
Asparagus:										
Blanched[2]		[3] 16–20				[4] 16–20			7	New York State
Beans, snap:										
Blanched[2]		0	0	33		22	3	47	12	Massachusetts
Not blanched		39	24	75		74	39	90	12	Do.
Peas:										
Blanched[2]		[3] 5–25				[4] 5–25			5	New York State, Oreg.
				[3] 30–40				[4] 30–40	4–11	Washington
Peaches:										
Hot-lye-peeled, washed	[5] 25				[4] 25				6	New York State
Raspberries:										
Dry pack, no sugar added								19–24	9	Washington
Strawberries:										
Packed with sugar or sirup				10–20				up to 50	4	Montana

[1] In these columns the loss, expressed as percentage of the vitamin originally present in the fresh material, represents that incurred in the freezing process plus any additional loss during the storage period.
[2] Blanched and frozen according to regular commercial procedures.
[3] These losses occurred, not in the freezing process itself, but in the necessary preliminary blanching.
[4] Little or no additional loss of the vitamin in storage.
[5] This vitamin loss occurred in the peeling and washing preliminary to freezing.

The present urgent need to conserve all garden surpluses on the one hand, and, on the other hand, to use ration points wisely for what they will bring in quantity, quality, and nutritional values of foods, has brought up the question of the relative merits of freezing, canning, and dehydration as methods of conserving not only the foods but their nutritive value as well. The experimental studies included in this report are too few in number to permit of any broad generalizations, but they do indicate certain points concerning the effects of these processes on the vitamin values of foods.

Sharp freezing of vegetables appears to cause relatively small loss of thiamine—usually less than 25 percent—still smaller loss of riboflavin, but relatively larger loss of ascorbic acid, up to 30 to 40 percent. These relationships are indicated by the data summarized in table 46. The destruction of the vitamin seems not to occur in the actual freezing process, but to be associated with the necessary preliminary blanching or with the preliminary steps of washing and peeling, sorting, and grading. The importance of the blanching process is suggested by the much greater losses suffered by the unblanched vegetables in freezing and in subsequent freezing storage. During this storage period there may be little or no additional loss of the vitamin in some foods, whereas other foods show measurable losses, particularly of ascorbic acid.

Data on canning losses, summarized in table 47, indicate that fruit and fruit juices and tomatoes, all of which are acid, retain their ascorbic acid in the canning process and later storage period better than do the nonacid vegetables of which the snap beans are an example. Strawberries show larger losses of ascorbic acid in canning and subsequent storage than they do in freezing and freezing storage, and canned snap beans likewise show greater losses of thiamine, riboflavin, and ascorbic acid than occur in the frozen beans. At that, however, the canned beans, even after a year's storage, appear to retain not less than 50

TABLE 47.—*Vitamin losses in canning and in subsequent storage of canned products*

Product and procedure	Loss in canning			Total loss after storage of canned product[1]			Storage period	Station
	Thiamine	Riboflavin	Ascorbic acid	Thiamine	Riboflavin	Ascorbic acid		
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*		
Beans, snap:								
Blanched and canned[2]	17	<10	75	45	<10	75	1 year	Massachusetts
Blanched, parboiled, canned[3]	------	------	-------	------	------	73	3 years	Wyoming
Tomato juice:								
Processed in glass[3]	------	------	[4] 18–23	------	------	[5] 25–30	60 days	Arkansas
Processed in tin[3]	------	------	[4] 13–18	------	------	[5] 14–19	60 days	Do.
Grapefruit juice:								
Variously prepared and canned[2]	------	------	7–30	------	------	-------	----------	Texas
Strawberries:								
Canned[3]	------	------	50	------	------	80	9 months	Montana

[1] This loss represents that incurred in canning plus additional loss during storage.
[2] Prepared and canned under conditions of large-scale processing.
[3] Prepared and canned under home conditions.
[4] 10-15 percent loss occurred during juice preparation, the rest of the loss during processing.
[5] Only slight additional losses were observed with longer storage.

TABLE 48.—*Vitamin losses in foods upon drying and subsequent storage*

Product and procedure used	Loss in drying				Total loss after storage of dried product[1]				Storage period	Station
	Vitamin A (carotene)	Thiamine	Ribo-flavin	Ascorbic acid	Vitamin A (carotene)	Thiamine	Ribo-flavin	Ascorbic acid		
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*		
Beans, snap:										
Blanched, dehydrated[2]	----------	1.5	0	95	----------	16	0	96	1 year	Massachusetts
Carrots, small, young:										
Blanched, dehydrated	7–33	----------	----------	43–50	----------	----------	----------	----------	----------	Colorado
Peppers:										
Dehydrated[3]	54	----------	----------	63	(4)	----------	----------	(4)	----------	New Mexico
Sun-dried[3]	90	----------	----------	93	(4)	----------	----------	(4)	----------	New Mexico
Sweetpotatoes:										
Dehydrated[5]	7–50	----------	----------	----------	50–100	----------	----------	----------	----------	North Carolina, Louisiana
Eggs:										
Dehydrated[2]	0	----------	----------	----------	0	----------	----------	----------	14 weeks[6]	Indiana

[1] This loss, calculated as the percentage of the vitamin present in the original fresh food, includes the loss incurred in the drying or dehydration process plus additional loss during storage.
[2] Dehydrated on a commercial scale according to commercial procedures.
[3] Dehydrated or sun-dried by home methods.
[4] Destruction of the vitamin continued during storage.
[5] Dehydrated on a semicommercial scale.
[6] Stored at —18° C.

percent of their thiamine and not less than 90 percent of their riboflavin, although only about 25 percent of the ascorbic acid is retained.

Since thiamine, riboflavin, niacin, and ascorbic acid are all water-soluble, they dissolve in the canning brine, to which the vegetable loses from 30 to 50 percent of its vitamins. If this amount is not to be lost, the liquor in the can must be utilized along with the vegetable portion.

The few data from this report on vitamin losses in dehydration are summarized in table 48. They suggest that ascorbic acid, in vegetables in particular, may be largely destroyed in the dehydration process and almost completely lost after a few months of storage of the product. In some cases carotene is unstable to oxidation and much may be lost. With careful control of dehydration procedures and storage conditions, however, the losses of ascorbic acid and carotene may be greatly reduced. The B vitamins are comparatively stable during drying and storage.

In all three of these processes of preservation several points in common have been emphasized as favoring the maximum vitamin retention in the final product. First, is the selection of raw food of prime quality and maturity; second, immediate use of the food before it has time to decrease in quality and lose vitamin in storage; third, rapid handling of the food with proper blanching to destroy the enzymes which exert unfavorable effects on color, odor, and vitamin content; fourth, proper packaging; and fifth, utilization of the product within a year or less from the time it is prepared.

Whether the food comes to the kitchen in the fresh, the frozen, the canned, or the dehydrated state, it has still to be prepared and cooked and in these operations it is subject to further vitamin losses. The trimming, paring, and choice of portion utilized will have some influence on the vitamin value of the food as cooked. In fruits, for example, the skins and the tissue immediately beneath, and in cereals, the outer branny layers and the germ have been shown to carry higher concentrations of vitamins than do the inner tissues. These parts may well be eaten for their food value, unless undesirability of texture or other considerations make this practice seem unwise. The practice of discarding coarse midribs and leaf stems, or petioles, in the preparation of greens for table use, does not result in particular loss of nutritive value, since these structures have been shown to be much lower in vitamin content than the leaf blade itself. On the other hand, the practice of discarding the outer green leaves of headed forms, such as lettuce and cabbage, results in decided loss of vitamin values, since these outer leaves are much richer in carotene and ascorbic acid than are the inner bleached leaves.

In the experiments considered in this report cooking losses of one vitamin or another were determined in a number of foods cooked by various methods typical of those used in the home. The results, summarized in tables 49 and 50, show that, for the most part, the losses ranged from 0 to 33 percent if the cooking water was utilized but from 20 to 40 percent if the cooking water was discarded. The details of these studies indicate that in boiling, which is the most common method of cooking, neither the amount of the vitamin destroyed nor the amount dissolved is influenced by the composition of the cooking pan or by the use of an open or a covered pan. An increase in the amount of cooking water results in an increase in the amount of water-soluble vitamin (thiamine, riboflavin,

TABLE 49.—*Vitamin losses in cooking* [1]

Food	Ascorbic acid loss[2]		Nicotinic acid loss[2]		Thiamine loss[2]	Riboflavin loss[2]	Station
	Amount destroyed in cooking[3]	Amount in cooking liquid plus that destroyed[4]	Amount destroyed in cooking[3]	Amount in cooking liquid plus that destroyed[4]	Amount destroyed in cooking[3]	Amount destroyed in cooking[3]	
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	
Meat:							
Pork:							
Fresh			<10	15–35	[5] 30	[5] <10	Wisconsin
Vegetables:							
Flower forms:							
Fresh:							
Broccoli			8–35	8–41			New Jersey
Cauliflower			8–17	8–30			Do.
Frozen:							
Broccoli	8–21	18–47					New York State and (Cornell)
Fruit forms:							
Fresh:							
Papaya	7–12						Hawaii
Leafy forms:							
Fresh:							
Beet greens			12–16	16–23			New Jersey
Cabbage			21–26	21–30			Do.
Spinach			20–37	26–37			Do.
Turnip greens	25–32						Southern Cooperative

Legumes:							
Fresh:							
Beans, lima			0–20	10–25			New Jersey
Beans, snap			5– 8	16–47			Do.
Do.	24				10	0	Massachusetts
Peas	0– 9	14–46					Washington
Do.			2–10	24–34			New Jersey
Frozen:							
Beans, snap	12						Massachusetts
Peas	5–23	24–53			0	0	Washington
Canned:							
Beans, lima			0– 3	30–37			New Jersey
Beans, snap			5– 7	47–48			Do.
Do.	5– 6				0	0	Massachusetts
Peas			3– 9	36–41			New Jersey
Dry (mature):							
Beans, common or kidney			8–21	[6] 11–26			Do.
Dehydrated:							
Beans, snap	[7]				45	33	Massachusetts
Roots and bulbs:							
Fresh:							
Beets			2–21	32–37			New Jersey
Carrots			10–16	15–28			Do.
Onions		27					Maine
Parsnips	0–24	9–34					New York (Cornell)
Potatoes		6–23	3–11	7–23			Montana, New Jersey
Sweetpotatoes			2–15	6–18			New Jersey

[1] The cooking losses were those determined in foods cooked by various methods typical of those used in the home. Meats were roasted, braised, and broiled; vegetables were boiled, steamed, and cooked in a pressure saucepan, with various amounts of water and for various cooking times.
[2] Loss is expressed as the percentage of the amount of vitamin in the food as used for cooking, whether fresh, frozen, canned, or dried.
[3] This represents the loss if the cooking water, or in the case of canned goods, the liquid portion, is retained. In meats it is the loss if the drippings are used.
[4] This represents the cooking loss if the cooking water, or the liquid from the can, is discarded. In meats it is the loss if the drippings are discarded.
[5] The amount of vitamin in the drippings plus that destroyed in cooking amounted to 30 to 50 percent.
[6] The liquid in this case was the soaking water, which was discarded.
[7] Too small an amount of ascorbic acid was present in the dehydrated beans to allow for an accurate estimate of loss due to cooking.

TABLE 50.—*Vitamin losses in cooking* [1]

[A summary of data in table 49]

Food	Cooking water not discarded				Cooking water discarded	
	Ascorbic acid	Niacin	Thiamine	Riboflavin	Ascorbic acid	Niacin
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Meat:						
Pork:						
Fresh	----	<10	30	<10	----	[2] 20
Vegetables:						
Flower forms:						
Fresh	----	17	----	----	----	26
Frozen	12	----	----	----	35	----
Fruit forms:						
Fresh	10	----	----	----	----	----
Leafy forms:						
Fresh	29	22	----	----	----	25
Legumes:						
Fresh	5	7	10	0	30	23
Frozen	10	----	0	0	39	----
Canned	6	4	0	0	----	40
Dehydrated	[3]	----	45	33	----	----
Dry (mature)	----	13	----	----	19	----

[1] Losses, expressed as percentage of the vitamin in the food as used for cooking, were calculated, for the most part, as averages of the individual analyses reported.

[2] Thiamine and riboflavin losses for the cooked pork without drippings were 35 and 15 percent, respectively.

[3] The amount of ascorbic acid in dehydrated beans was too small to permit accurate estimation of cooking losses.

niacin, and ascorbic acid) dissolved, while an increase in the length of the cooking time increases the amount destroyed. In boiling, this latter effect is not so serious, but if a pressure saucepan is used great care must be taken to prevent overcooking, for the matter of even half a minute can cause a great increase in vitamin loss. Root vegetables, boiled whole and unpeeled, retain more of their vitamin than do those cut in small pieces. In the case of pared cut potatoes, soaking in salt water prior to boiling serves to reduce the vitamin loss in cooking.

Still another chance for loss of vitamin occurs when the cooked food is held in the warming oven or on the steam table prior to serving or is put away in the refrigerator to be used later as a left-over. More work needs to be done on losses occurring at these stages. Several of the studies have suggested, however, that these losses may be appreciable.

Considered individually, the studies discussed in this report throw light on particular causes for the variations in the vitamin content of foods. Taken collectively, they indicate that the various effects are cumulative and that the cooked food as finally eaten may contain a much smaller proportion of the vitamins originally present in the raw food than is generally appreciated. On the other hand, if garden-fresh foods are used and if they are prepared and cooked by methods giving maximum vitamin retention, the vitamin losses from fresh to cooked product may be small. Several of the investigations (*56, 145*) [8] planned to show these progressive losses will serve to illustrate the point.

Turnip greens, because of careful storage at 40° F. in the 24 hours following harvest, lost no more than 5 percent of their original ascorbic acid content. Of the vitamin that they still retained they lost only 25 percent

[8] See also footnote 5, p. 14.

upon boiling for half an hour. The total of the storage and cooking losses, calculated to the original fresh basis, was only 28 percent. A paired lot of the greens stored at room temperature for 24 hours lost about 25 percent of the ascorbic acid present at harvest. Upon cooking, these greens lost 32 percent of the vitamin still retained after storage, this being a higher loss than that suffered by the better preserved greens. The total loss in storing and cooking this second lot of greens amounted to 49 percent of the ascorbic acid originally present in the greens as harvested.

Another example is that of the cumulative effect of freezing and cooking on the ascorbic acid content of peas. Fresh peas when cooked lost from 14 to 46 percent of their vitamin content; frozen peas, similarly cooked, lost from 24 to 53 percent of the vitamin they contained in the frozen state. In the frozen state, however, they had already lost some of the ascorbic acid they originally contained as fresh peas, so that the total loss in freezing and in cooking, when calculated to the fresh raw basis, was from 45 to 66 percent, as against the 14 to 46 percent loss in the unfrozen peas.

The influence of freezing, canning, and dehydration on the vitamin content of green snap beans was observed in beans grown on the same plots and sampled at the same stage of maturity. These were subjected to the several processes, carried out according to commercial procedures, and were finally cooked. Thiamine, riboflavin, and ascorbic acid determinations at the various stages, together with other necessary observations, indicated the extent of the progressive vitamin losses. These results, conveniently presented in the accompanying chart, speak for themselves.

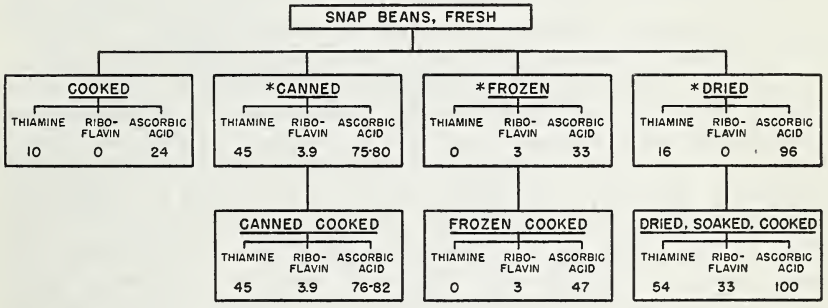

CHART 1.—Vitamin losses in processing and cooking snap beans. A measure of the total vitamin loss that may be expected from harvesting through processing and the final cooking of the processed product for table use is shown by the analyses of green snap beans carried through successive operations. These losses are expressed as percentages of the vitamins originally present in the fresh beans.

VITAMIN CONTENT OF FOODS—MISCELLANEOUS VALUES

If the vitamin intake of a population group is being estimated from data on the vitamin content of the raw foods applied to estimates of food purchases or of food consumption, large errors will arise in figuring the

intake unless a correction is made for the vitamin losses of various origin. These losses must also be considered by dietitians, commissary departments, and others seeking to make their food purchases cover the dietary needs of those in their charge. If, on the other hand, the vitamin contribution of a diet is being estimated from food-composition tables it is necessary, not to know what the losses have been, but rather, to know the vitamin value of the food as processed, as cooked, or as used in the diet. To serve this purpose, therefore, data on raw and processed foods, assembled from the studies reviewed in this report, are presented in the several tables that follow.

Analyses carried out in the investigations of factors affecting the vitamin values of foods yielded many data on samples in the stage of maturity, the processed condition, or other state characteristic of the foods as eaten. These data, together with values from other studies of vitamins in foods, are assembled for convenient reference in tables 52, 53, 54, 55, and 56. It should be stressed that the values in these tables represent the vitamin content of the particular samples analyzed and as such are not necessarily good average values for the food in question, since an average should be based on analyses of many samples representing the range of variability of the food. The data tabulated are taken from the sources noted, either directly or after summary and conversion to the units used in these tables. The reader is referred to these sources for further information concerning the nature and number of the samples and the methods of assay or analysis. In the tables are included data for many paired samples of raw and cooked or raw and processed foods. Vitamin losses due to cooking or processing are not to be estimated by comparison of these values, however, since such estimates require additional information concerning moisture or weight changes. Available data on vitamin losses are given in the preceding section of this report.

Among the foods included in the tables are a number of wild or native foods, such as the wild buffaloberries, huckleberries, and persimmons, wildrice, and native Hawaiian varieties of mangoes, papayas, and macadamia nuts. At a time when these wild or native foods should be used to supplement the none-too-sufficient supply of cultivated or commercial crops, it is well to learn what nutritive values they contribute to the diet. More of these wild foods available locally should be analyzed, since among them are probably some that could serve very well in an emergency as a rich source of ascorbic acid or other vitamin. The wild buffaloberries and persimmons, for example, are very rich in ascorbic acid, and even the dried persimmon leaves and the tea made from them are potent sources. Although we are accustomed to the use of citrus fruits for much of our ascorbic acid, it should be recognized that there are other foods that can be used toward meeting our requirement for this vitamin, especially in these days when it is necessary to make the most of the food at hand. A glance at the tables shows that strawberries, cantaloups, mangoes, and papayas, among the fruits, are also good sources of ascorbic acid, while among the vegetables many greens (tendergreens, turnip greens, sweetpotato tops, broccoli, kale, brussels sprouts, and spinach), cauliflower, and turnips are good sources, and peppers are an especially rich source, not only of ascorbic acid but of vitamin A as well.

Thiamine, in which American diets tend to be deficient, is present in

pork in relatively large amounts, as shown by the data tabulated. Whole-grain cereals are also good sources of this vitamin, as indicated by the data for brown rice, whole wheat, oatmeal, and wildrice. The high values for rice polish illustrate the fact, well known, that this vitamin is concentrated in the outer layers of the grain. When these are removed in milling, the resultant highly milled product, such as the polished rice, for example, contains but little of the thiamine. The process of soaking the rice before milling serves to dissolve the thiamine, which thus penetrates the kernel so that the "converted" rice obtained upon milling, although still not equal to the brown rice, is much richer in thiamine than the polished rice. Of the vegetables considered, dried legumes and fresh peas and asparagus are the only ones with thiamine contents sufficient to make a significant contribution to the diet.

Peas and asparagus are also rich in niacin, according to the data of Russell et al. (*130*) (New Jersey), who made a survey of the niacin content of a wide variety of fruits and vegetables. The following classification (table 51) taken from that report indicates how these various foods compare with regard to their content of niacin.

Another survey study giving data not heretofore available is that by Engel (*49*) (Alabama) who analyzed a large number of plant and animal tissues for their choline content. According to his findings, animal organs, egg yolk, and nerve tissue are considerably better sources of choline than any of the plant tissues analyzed. Green leafy plant tissue compares favorably with muscle tissue. Among the plant materials, green leafy and leguminous vegetables, seed oil meals, and grain germs are good sources of choline, with the seed oil meals equal or superior to the whole seeds. Skim milk powder appears to contain about a third more choline than whole milk powder.

Other investigations giving new data on the B complex vitamins in foods include the systematic investigation by Teply et al. (*143*) (Wisconsin) of the niacin, pantothenic acid, and pyridoxine content of many samples of wheat varying as to variety, class, and source; the analyses by Fish, as reported by Marsh (*91*) (West Virginia), of the various B vitamins in apples, which were found to be low in all of these vitamins; and the determinations by Haydak et al. (*66*) (Minnesota) of the B vitamins (and ascorbic acid) in honey, which was found to vary extremely in these constituents, depending probably on the source of the honey and the number of pollen grains present in the product.

A careful investigation by McIntire et al. (*86*) (Wisconsin) of pork cooked by standard procedures and sampled both with and without drippings, according to the manner of using such cooked meat in the home, showed thiamine and nicotinic acid values to be somewhat lower than previously reported but riboflavin values to be about the same as previously determined.

The data assembled from the many studies cited contribute to the information accumulating on the vitamin content of foods. In the case of those foods for which few, if any, data are available, the figures in the following tables will serve as tentative estimates of their vitamin content. For other foods, previously analyzed, the present data will serve toward defining the limits of variability and establishing more satisfactory averages.

TABLE 51.—*Classification of fresh vegetables, dried legumes, fresh fruits, and canned fruit juices ready for human consumption, according to nicotinic acid content per 100 grams of edible portion*

Range of amount	Vegetables			Legumes	Fruit	
	Raw	Cooked, fresh	Canned	Cooked, dried	Fresh	Juices, canned
100–500 micrograms	Celery Cucumbers Escarole Lettuce, head Onions Peppers, green Radishes Tomatoes	Beans, green Beets Beet greens Cabbage Carrots Cauliflower Potatoes	Beans, green[1] Beans, lima[1]	Beans, lima Beans, yellow eye	Apples Cherries Lemons Limes Oranges Strawberries	Apricot Grapefruit Orange Papaya Peach Pear Pineapple Plum Prune
500–1,000 micrograms		Beans, lima Broccoli Sweetpotatoes, yellow Spinach	Peas[1]	Beans, black turtle Beans, kidney Beans, navy Peas, split	Avocado Banana	Tomato
1,000–1,500 micrograms		Asparagus Peas				

[1] Per 100 grams of solid and liquid contents.

TABLE 52.—*Vitamin content of fruits and fruit products*

[Summary of recent data from agricultural experiment stations]

Fruit	Nature of sample	Vitamin content per 100 grams						Station	Literature reference
		Vitamin A		Niacin		Ascorbic acid			
		Average	Range	Average	Range	Average	Range		
		I. U.	*I. U.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Apples:									
Fresh	5–6 varieties, West Virginia grown			0.06	[1] 0.05–0.07	3	2– 4	West Virginia	(*91*)
	Peeled			.50				Wisconsin	(*142*)
Apricot juice:									
Canned				.14				New Jersey	(*130*)
Avocados:									
Fresh	6 varieties, Florida grown	[2] 475	217–850					Florida	(*60*)
				.97	.93–1.02			New Jersey	(*130*)
Bananas:									
Fresh				.61				Wisconsin	(*142*)
				.55	.46– .60			New Jersey	(*130*)

Blackberries:									
Fresh	Ripe. 2 varieties, North Carolina grown					18	13- 24	North Carolina	(*83*)
Blueberries:									
Fresh	Ripe. 4 varieties, North Carolina grown					18	16- 19	North Carolina	(*83*)
Buffaloberries:									
Fresh	Ripe. Native North Dakota fruit					184		North Dakota	(*79*)
Buffaloberry jam							80- 90	North Dakota	(*79*)
Cantaloups:									
Fresh	3 varieties, 2 regions, Florida grown	[2] 32,667					15–108	Florida	(*60*)
	Ripe. Arizona strain No. 45, variously grown					43	23- 61	Arizona	([3])
Cherries:									
Fresh				.14	.13- .14			New Jersey	(*130*)
Cranberries:									
Fresh				.13				Wisconsin	(*142*)
Dates				2.18				Wisconsin	(*142*)
Dewberries:									
Fresh	Ripe. 3 varieties, North Carolina grown					28	26- 32	North Carolina	(*83*)
Figs:									
Fresh	Celeste, Florida grown					0		Florida	(*60*)
Grapes:									
Fresh	3 varieties, Florida grown					0		Florida	(*60*)
	Pulp and juice, ripe muscadine. 7 varieties, North Carolina grown.					4	0- 7	North Carolina	(*8*)
	Thompson Seedless			.28				Wisconsin	(*142*)
Grapefruit juice:									
Fresh	From tree-ripened fruit. Rio Grande Valley					41	38- 46	Texas	(*59*)
Canned	109 samples, variously processed					34	26- 39	Texas	(*59*)
				.15	.14- .15			New Jersey	(*130*)
						34		Massachusetts	(*48*)
Honeydew melons:									
Fresh	Picked field ripe, analyzed after shipment					26	21- 28	Arizona	([3])
Huckleberries:									
Fresh	Wild, Florida grown	[2] 1,833						Florida	(*60*)
Lemons:									
Fresh				.17	.15- .19			New Jersey	(*130*)
Limes:									
Fresh				.25	.23- .28			New Jersey	(*130*)
Mangoes:									
Fresh	Ripe. 4 varieties, Hawaii grown					60	14–114	Hawaii	(*65*)
Oranges:									
Fresh				.20	.17- .22			New Jersey	(*130*)

TABLE 52.—*Vitamin content of fruits and fruit products—Continued*

Fruit	Nature of sample	Vitamin content per 100 grams						Station	Literature reference
		Vitamin A		Niacin		Ascorbic acid			
		Average	Range	Average	Range	Average	Range		
		I. U.	*I. U.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Orange juice:									
Canned				.15	.14– .16			New Jersey	(*130*)
Papaya:									
Fresh	Seedling, Florida grown					35		Florida	(*60*)
	Solo variety, 2 regions, Hawaii					84	59–118	Hawaii	(*65*)
Papaya juice:									
Canned				.09				New Jersey	(*130*)
Peaches:									
Fresh	Ripe. 8 varieties grown near Raleigh, N. C.					7	4– 13	N. C., Mass.	(*132*)
	Ripe. 17 varieties, Arkansas grown		33– 833					Arkansas	(*3*)
	Florida Honey variety	[2] 467				0		Florida	(*60*)
	Peeled, sliced. 5 varieties grown near Geneva, New York.	1,496	1,360–1,740					New York State	(*43*)
Frozen	do	1,488	1,340–1,730					New York State	(*43*)
Peach juice:									
Canned				.30				New Jersey	(*130*)
Pears:									
Fresh	2 varieties, Washington grown					2		Washington	(*152*)
	Peeled			.14				Wisconsin	(*142*)
Pear juice:									
Canned				.09				New Jersey	(*130*)
Persimmons:									
Fresh	Ripe. Native (Oklahoma-Missouri) varieties					100	95–105	Missouri, Oklahoma	(*150*)
Pineapple juice:									
Canned				.14				New Jersey	(*130*)
Plums:									
Fresh	Peeled			.56				Wisconsin	(*142*)
	2 varieties, Florida grown					0		Florida	(*60*)
Plum juice:									
Canned				.12				New Jersey	(*130*)
Prune juice:									
Canned				.42	.36– .46			New Jersey	(*130*)
Raisins				.63				Wisconsin	(*142*)
Raspberries:									
Fresh	Ripe. 3 varieties, North Carolina grown					26	20– 32	North Carolina	(*83*)
	4 varieties, Washington grown					20	18– 24	Washington	(*146*)
Frozen	Dry pack. Above 4 varieties					19	17– 19	Washington	(*146*)
	Dry pack, 1 part sugar : 4 parts berries					15	13– 17	Washington	(*146*)
Rhubarb:									
Fresh	2 varieties, Washington grown. From field and hothouse.					8	3– 17	Washington	(*144*)
Cooked	Baked, with added sugar and water					4	2– 5	Washington	(*144*)

Strawberries:									
Fresh				.25	.23– .26			New Jersey	(*130*)
	Missionary variety, Florida grown	[2] 1,217				30		Florida	(*60*)
	Ripe. 4 varieties, North Carolina grown					47	32– 66	North Carolina	(*21*)
	Ripe. 2 varieties, Montana grown					70	49– 91	Montana	(*94*)
Frozen	Dry sugar pack, 1: 4, freshly frozen					45	39– 54	Montana	(*94*)
	In 65 percent sirup. Drained berries					47	36– 57	Montana	(*94*)
	2 varieties, Washington grown					30		Washington	(*152*)
Canned	Freshly canned, 760 grams berries: 300 grams sugar.					26	25– 26	Montana	(*94*)
Strawberry jam	1 part sugar : 1 part berries						15– 34	Montana	(*94*)
	3 parts sugar : 2 parts berries, added pectin						9– 25	Montana	(*94*)
Strawberry jelly	With added pectin						9– 26	Montana	(*94*)
Strawberry preserves	1 part sugar : 1 part berries						8– 28	Montana	(*94*)
Watermelon:									
Fresh	2 varieties, Florida grown					0		Florida	(*60*)

[1] Average and range of values, in milligrams per 100 grams are reported for other members of the B complex: Thiamine, 0.011 (0.010-0.013); riboflavin, 0.010 (0.008-0.012); pyridoxine, 0.037 (0.031-0.043); inositol, 18.2 (7.7-39.0); pantothenic acid, 0.065 (0.055-0.070); *p*-aminobenzoic acid, 0.030 (0.022-0.038); and biotin, 0.011 (0.0008-0.0014).

[2] Values reported for "carotene" were assumed arbitrarily to represent β-carotene, and were converted to I. U. on the basis of 0.6 μg. of carotene being equivalent to 1 I. U. of vitamin A.

[3] See footnote 3, p. 9.

TABLE 53.—*Vitamin content of vegetables and vegetable products*

[Summary of recent data from agricultural experiment stations]

Vegetable	Nature of sample[1]	Vitamin content per 100 grams								Station	Literature reference
		Vitamin A		Thiamine		Niacin		Ascorbic acid			
		Average	Range	Average	Range	Average	Range	Average	Range		
		I. U.	*I. U.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Asparagus:											
Fresh:											
Raw	(1) New York grown, early and late harvests			0.18	0.17–0.18					New York State	(*101*)
	(2) Market samples					1.15	1.10–1.20			New Jersey	(*130*)
Cooked	(2a) Above samples boiled. Drained					1.04	.96–1.10			New Jersey	(*130*)
Frozen:											
Raw	(1a) Above New York samples after freezing			.15	.14– .15					New York State	(*101*)
	(3) New York grown, blanched and frozen			.20						New York State	(*100*)

TABLE 53.—*Vitamin content of vegetables and vegetable products—Continued*

Vegetable	Nature of sample[1]	Vitamin content per 100 grams								Station	Literature reference
		Vitamin A		Thiamine		Niacin		Ascorbic acid			
		Average	Range	Average	Range	Average	Range	Average	Range		
		I. U.	*I. U.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Beans, common or kidney:											
Fresh snap beans:											
Raw	(1) Peneil Pod Black Wax variety, South Dakota grown	[2]180	[2]166–193					13	12–15	South Dakota	(6)
	(2) Wax beans					.76				Wisconsin	(142)
	(3) Green beans					.64				Wisconsin	(142)
	(4) Young green beans, Massachusetts grown[3]			.06				26		Massachusetts	(56)
	(5) Green beans, market samples					.35	.34– .36			New Jersey	(130)
Cooked	(5a) Above samples boiled. Drained					.24	.18– .26			New Jersey	(130)
Frozen snap beans:											
Raw	(6) Commercially frozen			.06						New York State	(100)
	(4a) Green beans, blanched, frozen[3]			.08				15		Massachusetts	(56)
Canned snap beans:											
As opened	(4b) Green beans, blanched, canned[3]. Drained			.05				4		Massachusetts	(56)
	(7) Green beans, as canned. Drained					.20	.16– .23			New Jersey	(130)
Reheated	(7a) Can contents heated for serving. Drained					[.18]	[.16– .21]			New Jersey	(130)
Dehydrated snap beans:											
Raw	(4c) Young green beans, blanched, dehydrated[3]			.98				15		Massachusetts	(56)
Dry beans (including black turtle, kidney, navy, and others):											
Raw	(8) Dry pinto beans, Arizona grown				.50– .99					Arizona	(2)
	(9) Dry kidney beans					2.82				Wisconsin	(142)
	(10) Dry beans					1.65	1.32–1.91			New Jersey	(130)
Cooked	(10a) Beans soaked, then boiled in fresh water					.54	.46– .72			New Jersey	(130)
Beans, lima:											
Fresh:											
Raw	(1) Baby Potato variety, South Dakota grown	[2]375	[2]340–410					22	22–23	South Dakota	(6)
	(2) Market samples					.92	.84–1.07			New Jersey	(130)
Cooked	(2a) Above samples boiled. Drained					.78	.62–1.00			New Jersey	(130)
Frozen:											
Raw	(3) Commercially frozen			.09						New York State	(100)
	(4) Commercially frozen							20		New York State	(88)
Cooked	(4a) Boiled, method varied. Drained							[12]	[9–17]	New York State	(88)
Canned:											
As opened	(5) As canned. Drained					.35	.28– .44			New Jersey	(130)
Reheated	(5a) Can contents heated for serving. Drained					[.33]	[.29– .36]			New Jersey	(130)
Dry:											
Raw	(6) Dry lima beans					1.83				Wisconsin	(142)
	(7) Dry lima beans					1.37	1.27–1.52			New Jersey	(130)
Cooked	(7a) Beans soaked, then boiled in fresh water					.44	.40– .51			New Jersey	(130)

Beets:											
Fresh:											
Raw	(1)					.64				Wisconsin	(*142*)
	(2) Peeled					.17	.13– .23			New Jersey	(*130*)
Cooked	(2a) Above sample, boiled. Drained					.13	.09– .16			New Jersey	(*130*)
Beet greens:											
Fresh:											
Raw	(1) Detroit Dark Red variety, South Dakota grown	[2]4, 795	[2]4, 660–4, 930					20	15–24	South Dakota	(6)
	(2) Mississippi grown. Leaf blade only	[2]7, 148								Mississippi	(*134*)
	(2a) Mississippi grown. Petiole only	[2]996								Mississippi	(*134*)
	(3) Market samples					.31	.29– .33			New Jersey	(*130*)
Cooked	(3a) Above samples, boiled. Drained					.36				New Jersey	(*130*)
Broccoli:											
Fresh:											
Raw	(1) Market samples					.89	.79–1.05			New Jersey	(*130*)
Cooked	(1a) Above samples, boiled. Drained					.60	.46– .77			New Jersey	(*130*)
Frozen:											
Raw	(2) Blanched, frozen			.09						New York State	(*100*)
	(3) Oregon grown, commercially frozen							89	84–96	New York State	(*5*)
Cooked	(3a) Above sample variously cooked							63	48–83	New York State	(*5*)
Brussels sprouts:											
Frozen:											
Raw	Commercially frozen							63		New York State	(*88*)
Cabbage:											
Fresh:											
Raw	(1) Golden Acre variety, South Dakota grown	[2]232	168–295					29	25–32	South Dakota	(6)
	(2) Maine grown, held in commercial cold storage							48	36–56	Maine	(*30*)
	(3)					.23				Wisconsin	(*142*)
	(4) Market samples					.22	.12– .26			New Jersey	(*130*)
Cooked	(4a) Above samples, boiled. Drained					.18	.11– .22			New Jersey	(*130*)
Cabbage, Chinese:											
Fresh:											
Raw	(1) Tendergreens. Mississippi grown. Leaf blade only							166		Mississippi	(*134*)
	(1a) Tendergreens. Mississippi grown. Petiole only							42		Mississippi	(*134*)
Carrots:											
Fresh:											
Raw	(1) Danvers Half Long, South Dakota grown	[2]2, 425	[2]1, 730–3, 120					6	5– 6	South Dakota	(6)
	(2) 6 varieties, Colorado grown, small, young	[2][12, 383]	[2][11, 617–14, 233]					15	13–17	Colorado	(*124*)
	(3) 6 varieties, Colorado grown, large, mature	[2][35, 833]	[2][26, 833–47, 000]							Colorado	(*124*)
	(4)					1.47				Wisconsin	(*142*)
	(5) Market samples. Scraped					.29	.20– .34			New Jersey	(*130*)
Cooked	(5a) Above samples, boiled. Drained					.24	.18– .28			New Jersey	(*130*)
Dried:											
Raw	(2a) Above 6 varieties. Small young. Dehydrated	[2][90, 000]	[2][72, 833–113, 500]					70	67–74	Colorado	(*124*)
	(3a) Above 6 varieties. Large mature. Dehydrated	[2][232, 333]	[2][221, 667–238, 333]							Colorado	(*124*)

TABLE 53.—*Vitamin content of vegetables and vegetable products—Continued*

Vegetable	Nature of sample[1]	Vitamin content per 100 grams								Station	Literature reference
		Vitamin A		Thiamine		Niacin		Ascorbic acid			
		Average	Range	Average	Range	Average	Range	Average	Range		
		I. U.	*I. U.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Cauliflower:											
Fresh:											
Raw	(1) Snowball variety, South Dakota grown	[2]173	[2]172–175					86	85–88	South Dakota	(6)
	(2)					.57				Wisconsin	(142)
	(3) Market samples					.58	.48– .66			New Jersey	(130)
Cooked	(3a) Above samples boiled. Drained					.46	.41– .51			New Jersey	(130)
Frozen:											
Raw	(1) Blanched, frozen			.04						New York State	(100)
	(2) Commercially frozen							63		New York State	(88)
Cooked	(2a) Boiled; method varied. Drained							46	42–53	New York State	(88)
Celery:											
Fresh:											
Raw	Market samples					.21	.18– .26			New Jersey	(130)
Chard:											
Fresh:											
Raw	(1) Lucullus variety, South Dakota grown	[2]3, 354	[2]2, 868–3, 840					26	23–28	South Dakota	(6)
	(2) 2 varieties, Mississippi grown. Leaf blade only	[2][6, 150]	[2][2, 760–6, 450]					[33]	[32–34]	Mississippi	(134)
	(2a) 2 varieties, Mississippi grown. Petiole only	[2][199]	[2][198– 200]					[4]		Mississippi	(134)
Collards:											
Fresh:											
Raw	(1) Mississippi grown. Leaf blade only	[2][11, 758]						[110]		Mississippi	(134)
	(1a) Mississippi grown. Petiole only	[2][361]						[51]		Mississippi	(134)
Corn:											
Fresh sweet corn:											
Raw	Golden Cross Bantam—Type A, South Dakota grown	[2]227	[2]212– 240					9		South Dakota	(6)
	Fresh sweet corn							9		Massachusetts	(48)
Frozen sweet corn:											
Raw	Commercially frozen cut corn			.12						New York State	(100)
Cucumbers:											
Fresh:											
Raw	Early Cluster variety, South Dakota grown							5		South Dakota	(6)
	Michigan grown	259	216– 290	[.03]	[.02– .06]			[13]	[12–14]	Michigan	(22)
	Market samples					.14	.11– .17			New Jersey	(130)
						.32				Wisconsin	(142)
	Florida grown							0		Florida	(60)

Dock:											
Fresh:											
Raw	(1) Curly dock, Mississippi grown. Leaf blade only	[2][17, 695]						99		Mississippi	(*134*)
	(1a) Curly dock, Mississippi grown. Petiole only	[2][1, 085]						23		Mississippi	(*134*)
Eggplant:											
Fresh:											
Raw	Early Long Purple variety, South Dakota grown							3	3– 4	South Dakota	(6)
Escarole:											
Fresh:											
Raw	Market sample					.37				New Jersey	(*130*)
Kale:											
Fresh:											
Raw	Dwarf Curled variety, South Dakota grown	[2]3, 857	[13], 632–4, 083					67	54–77	South Dakota	(6)
Kohlrabi:											
Fresh:											
Raw						.27				Wisconsin	(*142*)
Lettuce:											
Fresh:											
Raw	(1) Head lettuce, market samples					.14	.10– .20			New Jersey	(*130*)
	(2) Grand Rapids, South Dakota grown	[2]563						32		South Dakota	(6)
	(3) Untrimmed market sample. Leaf blade only	[2][8, 138]						[28]		Mississippi	(*134*)
	(3a) Untrimmed market sample. Petiole only							[5]		Mississippi	(*134*)
Mushrooms:											
Fresh:											
Raw	*Agaricus campestris*[4]	0		.12		5.85		9		Massachusetts	(*1*)
Onions:											
Fresh:											
Raw	Sweet Spanish, South Dakota grown	[2]280	[2]210– 348					17	15–19	South Dakota	(6)
	10 varieties, Maine grown. Mature							16	13–22	Maine	(*107*)
	16 varieties, Maine grown. Mature and immature							26	17–40	Maine	(*107*)
						.10				Wisconsin	(*142*)
	Market sample					.18				New Jersey	(*130*)
Parsnips:											
Fresh:											
Raw	(1) New York grown, stored 1–5 months								7–30	New York (Cornell)	(*18*)
Cooked	(1a) Above samples, variously cooked								10–23	New York (Cornell)	(*18*)

TABLE 53.—*Vitamin content of vegetables and vegetable products—Continued*

Vegetable	Nature of sample[1]	Vitamin content per 100 grams								Station	Literature reference
		Vitamin A		Thiamine		Niacin		Ascorbic acid			
		Average	Range	Average	Range	Average	Range	Average	Range		
		I. U.	*I. U.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Peas:											
Fresh:											
Raw	(1) Alaska, South Dakota grown, in shade and in open	[2]230	[2]132– 328					34	32–36	South Dakota	(6)
	(2) 3 varieties, Oregon grown			.32	.31– .33					Oregon	(58)
	(3) Market samples					1.56	1.38–1.82			New Jersey	(130)
	(4) 2 varieties, Washington grown							26	24–28	Washington	(145)
	(5) 2 varieties, New York grown			.37	.31– .43					New York State	(101)
Cooked	(3a) Above market samples, boiled					1.08	.93–1.34			New Jersey	(130)
	(4a) Above Washington samples, boiled, steamed							20	15–27	Washington	(145)
Frozen:											
Raw	(6) New York grown, blanched, frozen			.26						New York State	(100)
	(2a) Above Oregon samples, blanched, frozen			.29	.26– .31					Oregon	(58)
	(4b) Above Washington peas, blanched, frozen							18	17–23	Washington	(145)
	(5a) Above New York peas, blanched, frozen			.31	.28– .34					New York State	(101)
	(7) Commercial quick frozen							21		New York State	(88)
	(8) Various commercial packs, 2 seasons							17	12–23	Washington	(145)
Cooked	(4e) Above frozen Washington peas, after boiling							13	10–18	Washington	(145)
	(7a) Above commercial quick-frozen peas, boiled							16	14–19	New York State	(88)
Canned:											
As opened	(9) Drained peas					.62	.51– .76			New Jersey	(130)
Reheated	(9a) Heated for serving. Drained					.60	.47– .75			New Jersey	(130)
Dry:											
Raw	(10) Split peas					2.49	2.16–2.78			New Jersey	(130)
Cooked	(10a) Split peas soaked, then boiled					.72	.60– .80			New Jersey	(130)
Peppers:											
Fresh (including pungent varieties ("chile") and sweet):											
Raw	Windsor A variety, South Dakota grown	[2]1,083	515–1,650					39	32–46	South Dakota	(6)
	8 varieties, New Mexico grown. Green	[2][717]	[2][200–1,233]					[192]	53–404	New Mexico	(111)
	8 varieties, New Mexico grown. Red (ripe)	[2][18,667]	[2][5,700–41,050]					[345]	278–560	New Mexico	(111)
Canned (pungent varieties):											
As canned	Home and commercially canned, green chile	[2][650]	[2][400– 917]					[81]	18–156	New Mexico	(111)
Dried (pungent varieties):											
Raw	Freshly dried by various home methods. Green	[2][2,717]	[2][650– 5,167]					[509]	[90–1,250]	New Mexico	(81)
	Freshly dried by various home methods. Red	[2][82,833]	[2][29,333–170,000]					[143]	81–212	New Mexico	(111)
Potatoes:											
Fresh:											
Raw	(1) Netted Gem variety, Montana grown							9		Montana	(129)
	(2) Warba variety, South Dakota grown							18	16–21	South Dakota	(6)
	(3) Peeled					1.18				Wisconsin	(142)
	(4) Market samples, peeled					.45	.36– .56			New Jersey	(130)
Cooked	(4a) Above samples boiled. Drained					.38	.23– .51			New Jersey	(130)

Radishes:											
Fresh:											
Raw	Market samples					.15	.14– .16			New Jersey	(*130*)
Radish tops:											
Fresh:											
Raw	(1) Mississippi grown. Leaf blade only	[2][11, 165]						[79]		Mississippi	(*134*)
	(1a) Mississippi grown. Petiole only	[2][665]						[15]		Mississippi	(*134*)
Spinach:											
Fresh:											
Raw	(1) King of Denmark variety, South Dakota grown	[2]2, 270	1, 990– 2, 548					54	46–63	South Dakota	(8)
	(2) Mississippi grown. Leaf blade only	[2][9, 314]						62		Mississippi	(*134*)
	(2a) Mississippi grown. Petiole only	[2][1, 170]						12		Mississippi	(*134*)
	(3)							66		Massachusetts	(*48*)
	(4)					¼ .72				Wisconsin	(*142*)
	(5) Market samples					.73	.70– .78			New Jersey	(*130*)
Cooked	(5a) Above samples boiled in minimum of water					.62	.60– .64			New Jersey	(*130*)
Frozen:											
Raw	(6) Commercially frozen							32		New York State	(*88*)
Sweetpotatoes:											
Fresh:											
Raw	(1) Peeled					1.29				Wisconsin	(*142*)
	(2) Market samples. Yellow, peeled					.65	.53– .79			New Jersey	(*130*)
Cooked	(2a) Above samples boiled. Drained					.57	.47– .74			New Jersey	(*130*)
Sweetpotato tops:											
Fresh:											
Raw	(1) Mississippi grown. Leaf blade only	[2][14, 100]						128		Mississippi	(*134*)
	(1a) Mississippi grown. Petiole only	[2][776]						15		Mississippi	(*134*)
Tomatoes:											
Fresh:											
Raw	(1) Bounty variety, South Dakota grown	[2]1, 308	[2]1, 270–1, 347					11	9–12	South Dakota	(6)
	(2) Farthest North C variety, Maine grown								29–35	Maine	(*30*)
	(3) 4 varieties, 4 Maine regions, 1939. Mature green							15	9–21	Maine	(*108*)
	(3a) 4 varieties, 4 Maine regions, 1939. Ripe							20	12–29	Maine	(*108*)
	(4) Mature, green, Hawaii grown (Oct.-Feb.)							14		Hawaii	(*65*)
	(5) Mainland grown, from Honolulu markets							15		Hawaii	(*65*)
	(6) Hawaii home garden plum tomatoes (July-Oct.)							27		Hawaii	(*65*)
	(7) Peeled					.58				Wisconsin	(*142*)
	(8) Market samples					.35	.28– .41			New Jersey	(*130*)

TABLE 53.—*Vitamin content of vegetables and vegetable products—Continued*

Vegetable	Nature of sample[1]	Vitamin content per 100 grams								Station	Literature reference
		Vitamin A		Thiamine		Niacin		Ascorbic acid			
		Average	Range	Average	Range	Average	Range	Average	Range		
		I. U.	*I. U.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Tomato juice:											
Canned:											
As opened	(1) Home canned (Farthest North C). Juice only[5]							18	15–21	Maine	(*30*)
	(1a) Home canned (Farthest North C). Juice and pulp[5]							25	18–34	Maine	(*30*)
	(2) Home canned, various methods. Freshly canned[5]								18–21	New York (Cornell)	(*63*)
	(2a) Home canned. Variously stored, 8½ months[5]								6–16	New York (Cornell)	(*63*)
	(3)							12		Massachusetts	(*48*)
	(4) [5]					.10				Wisconsin	(*142*)
	(5)					.54	.51– .56			New Jersey	(*130*)
Tomato catsup:											
Bottled	8 commercial brands. From store and packer							9	6–12	Massachusetts	(*52*)
Turnips:											
Fresh:											
Raw	Tokyo variety, South Dakota grown	[3]3,367	[3]3,323– 3,412					53	51–55	South Dakota	[6]
Turnip greens:											
Fresh:											
Raw	(1) Seven Top, Mississippi and Virginia. Leaf blade only	[2][14,484]						112		Mississippi	(*134*)
	(1a) Seven Top, Mississippi and Virginia. Petiole only	[2][607]						25		Mississippi	(*134*)
	(3) 2 varieties, 5 Southern States. Fresh and stored								121–145	Southern Cooperative	[7]
Cooked	(3a) Above samples boiled, not drained								82–105	Southern Cooperative	[7]

[1] Where paired samples are involved under a given food heading, items are so numbered and lettered that matched samples are designated by the same numeral while different treatments or parts are indicated by different letters.

[2] Values reported for "carotene" were assumed arbitrarily to represent β-carotene, and were converted to I. U. on the basis of 0.6 microgram of carotene being equivalent to one I. U. of vitamin A.

[3] Matched lots of Bountiful variety green snap beans were used for these fresh, frozen, canned, and dehydrated samples for which riboflavin values in milligrams per 100 grams are also reported, respectively, as follows: 0.13, 0.16, 0.13, and 2.02. Respective moisture values for the samples were 90.6, 92.3, 93.2 and 2.9 percent.

[4] Other vitamins reported for these mushrooms are riboflavin, 0.52 milligram per 100 grams; pantothenic acid, 2.38 milligrams per 100 grams; vitamin D, none; vitamin E, none; and vitamin K++.

[5] Data are reported in terms of 100 cc. portions.

[6] See footnote 2, p. 4.

[7] See footnote 5, p. 14.

TABLE 54.—*Vitamin content of cereals and cereal products*

[Summary of recent data from agricultural experiment stations]

Cereal	Nature of sample	Average vitamin content per 100 grams					Station	Literature reference
		Thiamine	Niacin	Pantothenic acid	Pyridoxine	Choline chloride		
		Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Barley:								
Whole	Red barley		4.70				Wisconsin	(*142*)
						139	Alabama	(*49*)
Pearled			2.75				Wisconsin	(*142*)
Corn:								
Whole	Yellow, 8 samples		2.1				Wisconsin	(*142*)
	Yellow					37	Alabama	(*49*)
Corn meal	Yellow		1.06				Wisconsin	(*142*)
	White		1.76				Wisconsin	(*142*)
	Bolted					10	Alabama	(*49*)
	Unbolted					42	Alabama	(*49*)
Corn germ	Raw corn germ stock					160	Alabama	(*49*)
Oats:								
Whole			1.36				Wisconsin	(*142*)
						94	Alabama	(*49*)
Oatmeal	Rolled oats	0.43					Hawaii	(*65*)
	do					151	Alabama	(*49*)
Rice:								
Brown:								
Raw	Whole brown, 7 lots, Louisiana and Arkansas grown	.30					Arkansas	(*72*)
			6.9				Wisconsin	(*142*)
Cooked	Cooked in oriental fashion	.10					Hawaii	(*65*)
Milled, parboiled	"Converted" rice. 3 varieties and regions	.16					Arkansas	(*72*)
Undermilled	2 varieties, Arkansas grown	.11					Arkansas	(*72*)
White, polished	Milled from above 7 lots of brown rice	.06					Arkansas	(*72*)
			.9				Wisconsin	(*142*)
						88	Alabama	(*49*)
Rice polish	Brush polish, from milling above 7 lots	2.10					Arkansas	(*72*)
	"Rice middlings" from local Hawaii mill	3.48					Hawaii	(*95*)
			96.6				Wisconsin	(*142*)
						126	Alabama	(*49*)
Rye:								
Whole			1.07				Wisconsin	(*142*)

TABLE 54.—*Vitamin content of cereals and cereal products—Continued*

Cereal	Nature of sample	Average vitamin content per 100 grams					Station	Literature reference
		Thiamine	Niacin	Pantothenic acid	Pyridoxine	Choline chloride		
		Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Wheat:								
Whole			6.0				Wisconsin	(*142*)
	55 samples varying as to variety, class, source[1]		5.9	1.33	0.46		Wisconsin	(*143*)
						92	Alabama	(*49*)
Wheat products:								
Bran			31.4				Wisconsin	(*142*)
						143	Alabama	(*49*)
Bread:								
White			.8				Wisconsin	(*142*)
"Enriched white"			1.5				Wisconsin	(*142*)
Milk bread			.9				Wisconsin	(*142*)
Whole wheat blend			1.8				Wisconsin	(*142*)
100 percent whole wheat			2.9				Wisconsin	(*142*)
Farina			.98				Wisconsin	(*142*)
Flour:								
Patent			1.0	.57	2.2		Wisconsin	(*143*)
	White					52	Alabama	(*49*)
Whole wheat		.35					Hawaii	(*65*)
Germ:								
Raw			3.4	1.53	.96		Wisconsin	(*143*)
			4.0				Wisconsin	(*142*)
						407	Alabama	(*49*)
Defatted			6.6				Wisconsin	(*142*)
						423	Alabama	(*49*)
Gluten			2.5				Wisconsin	(*142*)
Macaroni			2.1				Wisconsin	(*142*)
Wheatena						62	Alabama	(*49*)
Wild rice:								
Parched	Native Minnesota crop [2]	.47	6.1	1.01			Minnesota	(*110*)

[1] In these 55 samples the vitamin values, in milligrams per 100 grams, ranged from 4.7 to 10.6 for niacin; from 0.91 to 1.75 for pantothenic acid; and from 0.32 to 0.63 for pyridoxine.

[2] The vitamin values reported for these samples ranged, in milligrams per 100 grams, from 0.29 to 0.60 for thiamine; from 5.48 to 6.69 for niacin; and from 0.42 to 1.67 for pantothenic acid. Riboflavin, also determined, varied from 0.42 to 1.06 milligrams per 100 grams, with an average of 0.63 milligram.

TABLE 55.—*Vitamin content of meat and meat organs, fish, eggs, and milk*

[Summary of recent data from agricultural experiment stations]

Sample	Vitamin content per 100 grams								Station	Literature reference
	Thiamine		Riboflavin		Niacin		Pantothenic acid	Choline		
	Average	Range	Average	Range	Average	Range	Average	Average		
	Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Eggs:										
White					0.08			[<0.60]	Wisconsin, Alabama	(*142, 49*)
Yolk					.04			1,713	Wisconsin, Alabama	(*142, 49*)
Fish:										
Cod, filet, raw					2.3		0.4		Wisconsin	(*87, 151*)
Red snapper, muscle, raw								84	Alabama	(*49*)
Salmon, muscle, raw					7.4		1.8		Wisconsin	(*87, 151*)
Trout, muscle, raw								87	Alabama	(*49*)
Meat:										
Beef:										
Round, raw[1]					7.6	6.4–8.7	1.0	95	Wisconsin, Alabama	(*87, 151, 49*)
Round, roasted[1]					4.3				Wisconsin	(*87*)
Tongue					6.1		2.0		Wisconsin	(*87, 151*)
Chicken:										
Dark muscle, raw[1]					6.1		2.1		Wisconsin	(*87, 151*)
Light muscle, raw[1]					7.3		.8		Wisconsin	(*87, 151*)
Lamb:										
Leg, raw[1]					8.5		1.3		Wisconsin	(*87, 151*)
Shoulder, raw								119	Alabama	(*49*)
Pork:										
Ham, fresh:										
Raw					6.8	5.2–8.8	1.4	88	N. Dak., Wis., Ala.	(*27, 151, 49*)
Raw[2]	1.16	0.77–1.48	0.31	0.21–0.36	3.4	3.1–3.8			Wisconsin	(*86*)
Roasted[2]	1.05	.67–1.48	.35	.23–.43	4.1	3.5–4.7			Wisconsin	(*86*)
Braised[2]	.51		.22		3.6				Wisconsin	(*86*)
Broiled[2]	1.33	1.04–1.48	.41	.39–.44	4.0	3.2–4.7			Wisconsin	(*86*)
Ham, smoked:										
Raw[1]					5.9		1.7		Wisconsin	(*87, 151*)
Fried[1]					14.3		2.1		Wisconsin	(*87, 151*)
Loin:										
Raw		.95–2.39		.22–.32	6.3	4.3–8.9	1.7	77	Pa., N. Dak., Wis., Ala.	([3]), (*27, 151, 49*)
Raw[2]	1.21	.96–1.52	.26	.16–.30	4.0	3.1–4.9			Wisconsin	(*86*)
Roasted[2]	1.02	.79–1.42	.28	.17–.34	3.9	3.2–4.7			Wisconsin	(*86*)
Braised[2]	.80	.51–1.00	.26	.16–.33	3.5	3.0–4.0			Wisconsin	(*86*)
Broiled[2]	1.33	1.00–1.56	.37	.32–.44	5.2	4.9–5.4			Wisconsin	(*86*)
Shoulder, raw		.79–1.73		.32–.35				95	Pennsylvania, Alabama	([4]), (*49*)
Tongue, raw								138	Alabama	(*49*)
Veal:										
Hindquarter, raw[1]					8.3	6.8–9.1	1.1		Wisconsin	(*87, 151*)
Hindquarter, fried[1]					8.4				Wisconsin	(*87, 151*)
Rib roast, raw								82	Alabama	(*49*)

TABLE 55.—*Vitamin content of meat and meat organs, fish, eggs, and milk—Continued*

Sample	Vitamin content per 100 grams								Station	Literature reference
	Thiamine		Riboflavin		Niacin		Pantothenic acid	Choline		
	Average	Range	Average	Range	Average	Range	Average	Average		
	Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Meat organs:										
Brain:										
Beef, raw					4.9	4.7– 5.1	3.6		Wisconsin	(*87, 151*)
Hog, raw								375	Alabama	(*49*)
Heart:										
Beef, raw					7.6	7.0– 8.2	2.1		Wisconsin	(*87, 151*)
Beef, stewed					7.3		1.9		Wisconsin	(*87, 151*)
Calf, raw					10.6		2.5		Wisconsin	(*87, 151*)
Chicken, raw								236	Alabama	(*49*)
Hog, raw								231	Alabama	(*49*)
Kidney:										
Beef, raw					7.4	6.4– 8.3	4.0		Wisconsin	(*87, 151*)
Beef, stewed					5.2		4.0		Wisconsin	(*87, 151*)
Calf, raw								348	Alabama	(*49*)
Chicken, raw								223	Alabama	(*49*)
Hog, raw					9.8	9.1–10.5	3.3		Wisconsin	(*87, 151*)
Sheep, raw								360	Alabama	(*49*)
Liver:										
Beef, raw					18.7	15.1–22.7	6.7	630	Wisconsin, Alabama	(*87, 151, 49*)
Beef, fried					15.8		4.4		Wisconsin	(*87, 151*)
Calf, raw					17.6	13.2–20.2	6.0	652	Wisconsin, Alabama	(*87, 151, 49*)
Chicken, raw								342	Alabama	(*49*)
Hog, raw		.33– .53		4.05–4.38	22.8	18.7–29.8	5.4	552	Pa., Wis., Ala.	([3]), (*87, 151, 49*)
					14.5	13.5–15.7			North Dakota	(*37*)
Sheep, raw					17.2		6.9		Wisconsin	(*87, 151*)
Lung:										
Beef, raw					6.2		1.5		Wisconsin	(*87, 151*)
Pancreas:										
Beef, raw					5.8		2.4		Wisconsin	(*87, 151*)
Hog, raw								329	Alabama	(*49*)
Spleen:										
Beef, raw					7.2	6.2– 8.2	1.3		Wisconsin	(*87, 151*)
Beef, stewed					6.3				Wisconsin	(*87*)
Hog, raw								208	Alabama	(*49*)
Milk:										
Fresh whole					.08			14.7	Wisconsin, Alabama	(*142, 49*)
Acidophilus					.08				Wisconsin	(*142*)
Evaporated					.18				Wisconsin	(*142*)
Dried whole								107	Alabama	(*49*)
Dried skim					.89			159	Wisconsin, Alabama	(*142, 49*)
Human					.26				Wisconsin	(*142*)

[1] The samples analyzed were dried samples of meat that had been trimmed of surface fat. Cooked samples had not been prepared and cooked by properly standardized methods.

[2] The meats in this series were prepared and cooked, without seasoning, by standard procedures. Cooked meats were analyzed without drippings.

[3] See footnote 4, p. 11.

TABLE 56.—*Vitamin content of miscellaneous foods*

[Summary of recent data from agricultural experiment stations]

Food	Average vitamin content per 100 grams						Station	Literature reference
	Vitamin A	Thiamine	Riboflavin	Niacin	Choline	Ascorbic acid		
	I.U.	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*		
Alfalfa leaf meal	------	------	------	------	133	------	Alabama	(*49*)
Honey[1]	------	0.006	0.061	36.0	------	2.4	Minnesota	(*66*)
Macadamia nuts, cooked	0	.408	------	------	------	------	Hawaii	(*96*)
Peanuts	------	------	------	------	162	------	Alabama	(*49*)
Peanut butter	------	.380	------	18.6	145	------	Hawaii, Wisconsin, Alabama	(*97, 142, 49*)
Pecans, 4 varieties (Arizona grown)	------	.694	.106	------	------	------	Arizona	(*2*)
Persimmon leaves, green	------	------	------	------	------	2,726	Missouri, Oklahoma	(*150*)
Persimmon leaves, dried	------	------	------	------	------	3,585	Missouri, Oklahoma	(*150*)
Pickles, sweet and dill	450	.0	.028	------	------	2.1	Michigan	(*22*)
Yeast, dried brewers', bakers'	------	------	------	50	------	------	Wisconsin	(*142*)

[1] Pyridoxine and pantothenic acid also determined in these same samples of Minnesota honeys averaged 0.299 and 0.105 milligrams per 100 grams, respectively.

PRESERVATION OF FOODS

Because preservation markedly influences food values, and, more especially, because it is a very necessary phase of the food program, it is the aim in this section of this report to indicate the scope of experiment station contributions in regard to the preservation of foods by freezing, dehydration, canning, and other methods. These studies will be cited without attempt to discuss them, since their value lies chiefly in the detail and the specific information they offer. A few of the studies to be noted have been discussed briefly in previous reports (*137, 138*). They are cited in the present summary, however, because of the contribution they make and because of the need for bringing together at this time the pertinent information available from experiment station research on food preservation.

COMMON AND COLD STORAGE

Common storage, still a very important method in some sections for holding certain fruit and vegetable crops over a long supply period, reduces the quantity of these foods that must be canned or otherwise preserved. It is not only an economical practice, but also one which contributes to the war effort by reducing transportation requirements and releasing strategic materials. Storage satisfactory for conserving quality and nutritive value and preventing spoilage requires attention to temperature, humidity, aeration, light, and condition and variety of the crop. Binkley (*11*) considers these factors with special reference to storage crops commonly held in Colorado and discusses the reasons for the choice of particular conditions. An experimental Victory Garden storage cellar designed by A. D. Edgar (United States Department of Agriculture) for use in the Colorado storage studies is illustrated and described briefly with reference to its special features. Storage of vegetables commonly grown in Illinois is discussed by

Weaver (*153*), who summarizes the different temperature, humidity, and ventilation conditions necessary for successful storage of those crops that can be stored and offers working plans for the construction of facilities to meet these conditions.

Refrigerated farm storage to care for perishable crops, particularly fruits, is of interest to many growers because it is cheaper than commercial storage, permits choice of a market, and eliminates the necessity of grading and packing at picking time. Cardinell (*23*) points out that retired refrigerator cars removed from their trucks and placed on suitable foundations in the farm orchard may serve as satisfactory cold-storage houses at reasonable cost of purchase and upkeep. His report of tests with two identical cars, one refrigerated with ice, the other by a mechanical system, would be of interest to growers contemplating a shift to farm refrigeration, if retired cars were available.

Another study involving storage preservation of fruits and vegetables is one conducted by the Florida station on methods of wrapping and packing fresh Florida produce to maintain it in the best of condition in the interval between harvest and sale on the retail market. The very satisfactory results obtained with pliofilm and plioseal are indicated in the report of the study by Stahl and Vaughan (*140*). Pliofilm, a synthetic moistureproof plastic highly permeable to carbon dioxide and with other qualities making it particularly adaptable as a wrapping material, contains rubber hydrochloride as its principal base. Because of its content of strategic rubber it is not now available, but its possibilities in preserving fruits and vegetables in shipping should be kept in mind for post-war application.

FREEZING AND FROZEN STORAGE

The shortage of strategic materials has imposed major readjustments in the canning industry and has limited home canning. These limitations, coupled with the necessity for reducing space requirements in transportation, have given impetus to food-preservation processes that require the minimum of the critical materials and that reduce the bulk of the packaged food. Preservation by quick freezing is a procedure which fits in with these requirements and is a method which has received attention in experiment station research.

General methods and specific techniques.—The rapid development of refrigerated lockers in the United States brought with it the need for careful study of the factors involved in the production of quality products. Such studies have been carried out by many of the stations. Their findings on freezing and subsequent locker storage of fruits and vegetables, together with recommendations based on the practical experience of the trade, have been summarized in a number of publications issued in response to popular demand. Among these are findings based on the researches of the following stations: Colorado (*10, 123*), Georgia (*158*), Illinois (*74*), Iowa (*121*), Kansas (*57*), Michigan (*133*), Minnesota (*155, 156*), New Jersey (*28*), New York (Cornell) (*93*), North Dakota (*75, 76, 77, 78*), Oklahoma (*114*), Tennessee (*24*), and Washington (*115*). The material presented in the several publications varies somewhat in detail and scope, but in general it covers equipment; kinds and varieties of fruits and vegetables for freezing; selection as to maturity, condition, and quality; preparation; packing

(with reference to containers and the use of brine, sugar, and sirup); labeling of packed products; freezing; storing; and utilization of frozen products and their handling and cooking in the home. Comparable information on the freezing preservation of meat and poultry is based on research of the Kansas (*57*), Michigan (*12*), and New York State (*45, 93*) stations.

Special foods.—As a result of research, Plagge and Lowe (*120*) (Iowa) recommend the freezing of various fruits and vegetables—Swiss chard, kale, pineapple, and hybrid plums, to mention a few of them—not ordinarily frozen at present. Frozen eggs, their preparation and freezing, and use in making cakes, are discussed by Woodroof (*159*) (Georgia), and Schaible and Card (*131*) (Michigan) offer a method for producing and packaging frozen eggs in a form suitable for distribution in retail outlets and convenient for kitchen use.

Factors affecting quality.—Special studies have shown that quality control in frozen foods depends on certain particular factors whether the foods are prepared on a small scale in the home for locker freezing and storage, or on a commercial scale. DeFelice (*44*) (New York State) indicates that problems of variety and maturity must be solved; the importance of blanching and the necessary equipment required for this process are considered by Bull (*20*) (Illinois); and Carlton (*25*) (Tennessee) and Plagge (*119*) (Iowa) both stress the importance of variety, prime condition and maturity of the fresh material, prompt handling, excellent sanitation, proper packaging, and close wrapping. Factors influencing the texture and quality of asparagus, lima beans, peas, and peaches have been investigated, respectively, by Joslyn and Kilner (*69*) (California), Woodroof and Tankersley (*163*) (Georgia), Boggs et al. (*14*) (Washington), and Cox and MacMasters (*32*) (Illinois). Winter (*157*) (Minnesota) has shown that substitution of corn sirup for some of the sugar eliminates the recrystallization of sugar sometimes occurring in freezing. With regard to meats, Du Bois et al. (*46, 47*) (New York State) report on the effect of rate of freezing and temperature of storage on the quality of frozen meat and poultry; Bray et al. (*17*) (Kansas) consider the influence of freezing on tenderness in aged beef; Wellington et al. (*154*) (Kansas) and also Young and McIntosh (*165*) (Washington) discuss pork storage in freezer lockers; and Shrewsbury et al. (*135*) (Indiana) report on the chemical, histological, and palatability changes in pork during freezing and in frozen storage.

Frozen-food containers and container materials.—Although containers for practically all types of frozen foods have been perfected, recent restrictions in the use of certain critical materials (rubber, tin, waterproof lacquers, waxes, resins, and even paraffin) have removed some of the choice packaging materials from the market, but in substitution new types of packages and materials have been introduced. Woodroof and Du Pree (*161*) discuss their experience with many of these in tests conducted in a project sponsored jointly by the Tennessee Valley Authority and the Georgia station. They give data on more than 5,200 weighings of 5 frozen food products placed in packages of approximately 100 kinds and combinations of packaging materials over a period of 1 year. Their recommendations, based on these findings, stress the importance of the use of paraffin, and point out that every package must have a water-impervious film, and that one such film is enough.

Farm and domestic freezing plants and cabinets.—Because the freezer locker rental service has developed a desire for individual freezers that would eliminate the necessity of taking meat, fruits, and vegetables to and from the community plant, several stations have developed equipment and methods for freezing and storing farm produce. Rapid extension of electrical service to farms has aided in making such development feasible. Preliminary reports by Redfield and Witz from the Indiana station (*126*) indicate that the results of performance tests, and studies of costs of construction and operation of a number of units, are being used as a basis for developing a freezing unit that will be economical, suitable for farm construction, and adequate for the needs of the farm home. Three domestic-type frozen-food cabinets developed at the Pennsylvania station (*113*) and assigned to use by four families gave satisfactory performance in the freezing and frozen storage of various fruits, vegetables, and meats prepared according to standard practices. Plans, specifications, and construction and operation details have been issued by the Oregon station (*92*) for two types of farm freezing plants. The one meets the requirements for freezing only fruits and vegetables; the other, a two-compartment complete farm freezer plant, is adequate for the freezing and preservation of fruits, vegetables, and meats in sufficient quantity to meet the needs of the larger farm family.

DEHYDRATION AND SUN-DRYING

The drying of foods, particularly by dehydration (drying by artificially produced heat under controlled conditions of temperature, humidity, and air flow), is receiving special attention as a wartime measure of conservation. The advantages of the method are that it requires comparatively little of the critical materials for the processing operations and packaging; that it greatly reduces the bulk of the finished product and thereby facilitates shipping; and that it is adaptable to small-scale use in the home or to commercial procedures. Recent work has solved many of the problems involved in the drying of foods so that some of the products now being prepared are acceptable from the standpoint of keeping quality, and of flavor, texture, and color after rehydration and cooking.

Methods and equipment.—In line with the need for putting into use this important method for wartime conservation of food, a number of publications have been issued, giving general information and practical directions for home drying of fruits and vegetables. This information is based on the findings of nonstation workers and on the results of trials at the following experiment stations: California (*37*), Colorado (*122, 124*), Georgia (*162*), Illinois (*4*), Indiana [9], Massachusetts (*42*), New Jersey (*80*), New Mexico (*81*), New York State (*68, 112*), Pennsylvania (*90*), Rhode Island [10], Tennessee (*136*), Utah (*141*), and Washington (*7*); cooperative research of the Georgia, Tennessee, and Virginia stations, the Appalachian Electric Power Co., and the Tennessee Valley Authority provided information for a cooperative publication sponsored by the Southern Committee of Agricultural Extension Editors (*62*).

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[9] PURDUE UNIVERSITY. HOME DEHYDRATION OF FRUITS AND VEGETABLES. Purdue Agr. Ext. [unnumbered pub.], 8 pp., illus. [1943.] [Processed.]

[10] DYKSTRA, P. H. THE DEHYDRATION OF RHODE ISLAND FRUITS AND VEGETABLES. R. I. Agr. Expt. Sta. Misc. Pub. 16, [6] pp. 1943. [Processed.]

These guides to drying, chiefly by dehydration, vary somewhat in scope and detail but, in general, they consider factors governing small-scale or home dehydration of vegetables, the design and construction of small dehydrating units, the preparation of fruits and vegetables for drying, the operation of the dehydrator, and the costs of construction and operation. Points stressed are the necessity of selecting firm, ripe raw material; rapid but careful preparation of the raw food for drying; the desirability of sulfuring certain fruits to maintain quality and color; the necessity of blanching in order to maintain quality and reduce cooking time; careful attention to temperature, humidity, and air flow in order to prevent case-hardening and to bring about satisfactory reduction in moisture content; proper packaging in vaportight containers; storage in a cool dry place; and rehydration of the dehydrated product before cooking. The construction and operation of community- or farm-size dehydrators are considered in several of the publications previously mentioned (*42, 122, 124, 136, 162*).[11]

Dehydration on a commercial or semicommercial scale has also been given attention in experiment station investigations. Cruess and Mrak (*40*) (California) in a series of articles on the dehydration of vegetables summarize information available on this subject up to 1941-42. They have included this information, together with additional illustrations and a tabular summarization of the procedures for preparing and dehydrating the various vegetables, in a special subsistence bulletin prepared for the Quartermaster Corps of the War Department (*103*). Another technical summary of similar nature is one by Tressler (*147*). Information and recommendations based on recent station research, and on recent experience of the trade, are summarized in a paper by Cruess (*33*) on the dehydration of fruits and vegetables. The newly developed procedure of pressing dried vegetables into bricks freed from air is described in a report from the New York State station (*112*). This new packaging process insures the retention of color, flavor, and nutritive value.

In certain localities, particularly in California, freestone peaches, apricots, figs, pears, and nectarines are nearly always sun-dried, and other fruits may also be so dried. Methods and equipment for the sun-drying of these fruits are considered in detail by Mrak and Long (*104*). The advantages of dehydration over sun-drying in the production of dried fruits is discussed by Mrak et al. (*105*) in a recent paper in which it is pointed out that blanching and dehydration have produced a striking improvement in the products of the dried-fruit industry. Oregon's food dehydration program for handling the available fruit crops is outlined by Wiegand and Price.[12]

Dehydration of special products.—The war emergency in food preservation has spurred efforts to extend the dehydration process to foods not hitherto preserved by this method, and results of trials with a number of such products have been reported. These include dried citrus fruits for marmalade (*41*), dehydrated cherries (*106*), guavas (*102*), huckleberries (*61*), and pineapple (*34*), and dehydrated sauerkraut (*35*), baked beans (*51*), olives (*38*), and food specialties (*39*).

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[11] See also footnote 9, p. 77.

[12] WIEGAND, E. H., and PRICE, F. E. OREGON'S FOOD DEHYDRATION PROGRAM. Oreg. Agr. Expt. Sta. Cir. Info. 274. 18 pp. 1942. [Processed.]

CURING AND SMOKING, BRINING AND SULFURING

Curing and smoking of meats, brining of vegetables, and sulfuring of certain fruits are methods that can be used to extend the food preservation program. Their applicability in home or commercial processes has recently been investigated in the experiment station researches noted below.

Curing and smoking of pork and lamb.—Since the probable increase in freezer-locker storage for the conservation of wartime food supplies will strain locker capacities to the utmost, Bull (*19*) (Illinois) has recommended that the heavier cuts of pork be cured and smoked, rather than frozen, thus relieving much-needed locker space to accommodate frozen cuts from additional animals. This recommendation is accompanied with instructions for home curing of these heavy cuts—hams, bellies, and pienics—by sweet pickle or dry cure, followed by soaking to remove excess salt, and finally by smoking in a smokehouse or, lacking that, in a barrel. Brief directions are also given for artery pumping to facilitate the curing of heavy hams. Methods for hastening absorption of salt in farm-cured ham and the smoking and production of ready-to-eat hams have been investigated by Zeigler and Miller (*166*) (Pennsylvania). From trials conducted at the Oklahoma station a method was developed for curing lamb for farm family use. This method, reported by Beall and Purdy (*6*) involves chilling the lamb for approximately 48 hours at about 35° F.; curing in an 8 : 2 : 2 (salt, sugar, sodium nitrate) brine for 30 to 40 days, followed by brief soaking (2 hours) and overnight drying; and finally, light smoking.

Salting or brining of vegetables.—Salting or brining offers another method for preservation of vegetables that has the advantage of not requiring critical materials in either the processing or the packaging operations. Preliminary experiments at the Michigan station on salting peas, lima beans, snap beans, corn, and okra on a commercial scale indicate that salting can be used to good advantage in preserving vegetables. The results obtained show that this method is especially adapted to green snap beans, corn, and okra. Details of the salting procedure and of the results are presented by Fabian and Blum (*55*). Results of further tests on these and other vegetables (onions, cauliflower, green tomatoes, and cabbage) handled on a home-production scale are reported by Fabian (*54*). Commercial brine preservation of vegetables was also investigated in cooperative experiments by the U. S. Department of Agriculture and the North Carolina station. Brief recommendations based on these tests are given by Etchells and Jones (*53*) for the routine salting of a number of vegetables by three different procedures. Some of the salted products when desalted and cooked resemble similar canned vegetables in appearance. In other products the texture and flavor are somewhat altered but are entirely satisfactory.

In anticipation that pickling and brining, once so commonly used in the home, would be revived as a popular home method for wartime preservation of certain vegetables, a number of the stations have prepared directions for such procedures to help the homemaker in her conservation efforts. The making, canning, and utilization of home-made sauerkraut is considered by Pederson (*116*) in a circular recently reprinted to meet requests for this information; Richardson and Mayfield (*128*) give directions for pickling cucumbers and beets, krauting cabbage and

turnips, and brining asparagus, beans (lima, snap), broccoli, carrots, cauliflower, greens, peas, peppers, and squash; and Pyke and Dyar (*125*) summarize procedures for pickling and brining these and other vegetables by methods employing either a high-salt, a low-salt, or a dry-salt brining procedure.

Sulfuring of fruits.—Although the use of sulfur dioxide for the preservation of fruits is limited in the United States to a very few special products, its value as an effective and economical method of preserving fruits and fruit products is recognized. Since Great Britain imposes no restrictions on the use of sulfur dioxide as a fruit preservative, it has been employed, with great success, in the preservation of large quantities of fruits shipped to England under the lend-lease program for use in preserves. In order to evaluate the sulfuring process as compared with other methods being used in America and to collect additional data that might be of value to the British food program, extensive studies were undertaken at the Georgia station. Reports on these by Woodroof and Cecil (*160*) concern the methods employed in preserving with sulfur dioxide; the problems involved, particularly in the removal of sulfur dioxide from the product in preparation for consumption; and the results obtained. In these tests the sulfur dioxide solution was found to be an efficient and economical preservative for peaches, strawberries, dewberries, blackberries, and other fruits and fruit pulps. Commercial experience has proved that its use is extremely economical and that it requires less strategic materials than any other available method.

CANNING

Although freezing and dehydration and other processes will care for some of the food to be preserved for the winter, canning, particularly in the home, will be the method employed for conserving much of the surplus garden crop. In line with this canning program a number of recent bulletins have been issued to cover special canning problems and to meet the needs of the many homemakers canning for the first time in order to make full use of the Victory Garden harvest.

An adequate supply of containers and seals is one of the first essentials in a home canning program, and at canning time the thrifty housewife searches her cupboards and shelves for all available jars. In addition to the common types of home canning jars, she may use many of the commercial glass jars, such as those that contained salad dressing, pickles, coffee, peanut butter, and other foods. Such commercial jars have accumulated in most homes but there is much confusion with regard to their re-use for home canning, because of the varied kinds of caps originally used to seal them. Helpful notes on how to re-use these jars is given by Esselen (*50*), who points out which of the commercial jars are suitable for use in home canning, how they may be identified, and the types of home canning seals that are required to seal them. A good description is also given of the six common types of home canning jars in general use today, these differing mainly in the means of sealing employed.

Procedures for the preparation and canning of various products are considered in other publications. Methods for home preservation of fruit and vegetable juices developed at the New York State station are described by Tressler and Pederson (*148*). Modifications of these pro-

cedures for commercial preparation of the juices are discussed by Tressler et al. (*149*). Particular adaptations for the preparation and preservation of berry juices are given by Pederson and Beattie (*117*). General directions and certain particular details for the home preservation of fruit and vegetable juices are also summarized by Clark (*29*).

In the canning of whole tomatoes, particularly those picked later in the season, when they have matured and softened, there may be a tendency for the tomatoes to fall apart in cooking. The quality of these whole home-canned tomatoes may be improved by a procedure suggested by Kertesz (*70*). His work at the New York State station showed that calcium chloride, added to the extent of 10 grains per quart jar, is very effective in causing whole canned tomatoes to retain their firmness.

A publication by Richardson and Mayfield (*127*) deals with fruit preservation in wartime by canning, freezing, dehydration, and conversion to jam or jelly, the latter process with the use of corn sirup or honey to replace part of the sugar ordinarily used. The fruits considered are those commonly available in Montana. Pyke and Dyar (*125*), discussing wartime fruit canning, likewise point out that honey, or corn sirup sweetened with saccharin soluble to give it essentially the same sweetening power as table sugar, may be used to supplement wartime canning sugar allotments. General directions are given for preparing these sweetening agents, and methods of preparation and processing times are summarized for the fruits commonly grown in Colorado.

The method of canning with a pressure cooker is briefly outlined by Charley and Noer (*26*), and a study of the effectiveness of heat penetration in meat canned in glass jars in a pressure cooker is presented by Nelson and Knowles (*109*) (North Dakota).

Although a pressure cooker is generally considered essential for safe canning of meats and nonacid vegetables, the difficulty in obtaining pressure cookers under wartime restrictions has led many to use the boiling-water bath method. If a pressure cooker is not used, the canning bulletins warn, all home-canned nonacid foods must be boiled 15 minutes before they are tasted because of the possibility of botulinus. Even a sip of the juice of such foods can be fatally poisonous if they are not boiled after opening to destroy the botulinus toxin.

A recent revision by Cruess and Christie (*36*) of a home canning bulletin issued by the California station gives instructions concerning equipment and procedures for the canning of fruits, vegetables, and meats, and also includes a brief section on food poisoning. This material, prepared by K. F. Meyer and J. C. Geiger, offers for the guidance of physicians and health officers a tabulated comparison as to incubation period, treatment, investigation procedure, and symptomatology of general food poisoning and botulism, either of which might occur from tasting spoiled canned food.

A method for processing nonacid vegetables by the boiling-water bath method with little danger of the development of botulinus has been developed at the Colorado station. This method, described by Pyke and Dyar (*125*), involves the use of citric acid or vinegar to acidify the vegetables. The amounts of these edible acids required to convert nonacid-type vegetables into products which behave as acid-type foods during canning are noted, and the processing times required at various high altitudes are specified. These home-acidified nonacid canned foods are said

to be very palatable and the only limitation in using them is that they are not so readily combined with milk as the less acid foods.

Another particularly timely bulletin is one by Pfund (*118*), issued by the New York State Colleges of Agriculture and Home Economics. Canning methods, discussed in general from the standpoint of spoilage prevention, procedures, and equipment, are elaborated to give specific directions for various types of products. Special features of the bulletin are itemized "do's" and "don'ts" to guide the inexperienced, particularly, in expeditiously canning without risk of future spoilage; and a chart indicating which of the methods of preservation—storing, canning, freezing, dehydrating, pickling, or brining—are to be considered as preferred, good, or alternate for the various fruits and vegetables commonly preserved.

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